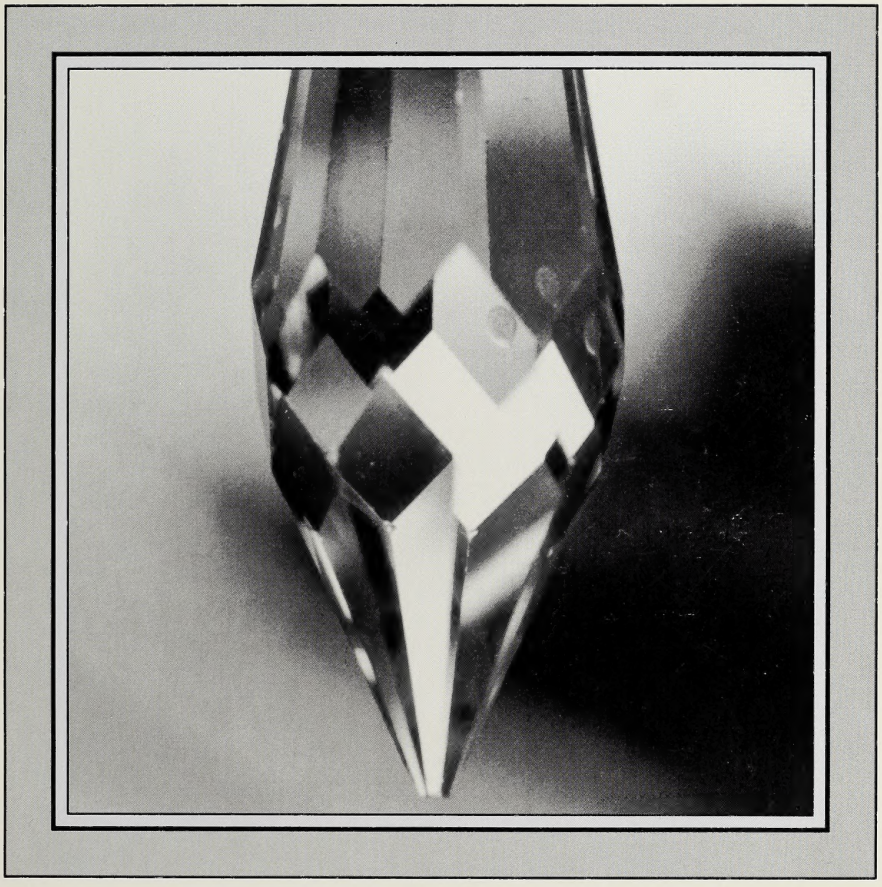
SCIENCE 24

Module 6: Exploring Nonmetals



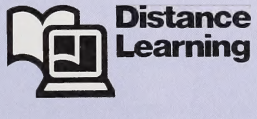
Distance Learning

Alberta EDUCATION

Science 24

Module 6

EXPLORING NONMETALS



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Other	

Science 24
Student Module
Module 6
Exploring Nonmetals
Alberta Distance Learning Centre
ISBN No. 0-7741-0818-5

Cover Photo: PHOTO SEARCH LTD.

Welcome to Module 6!

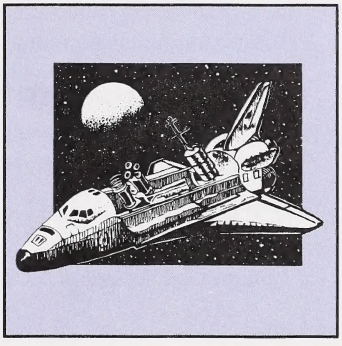
We hope you'll enjoy your study of Exploring Nonmetals.

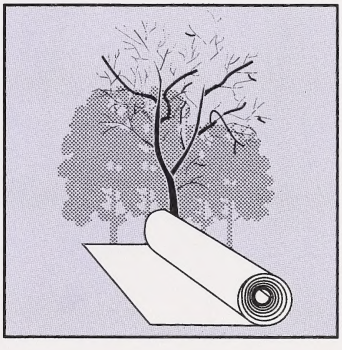
To make your learning a bit easier, a teacher will help guide you through the material.

So whenever you see this icon,

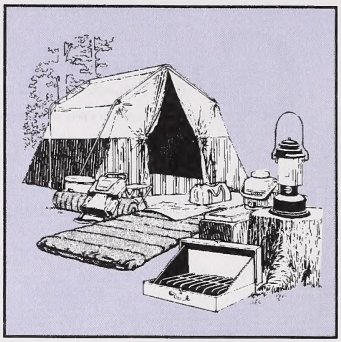
turn on your audiocassette and listen.

Contents





SECTION 3:



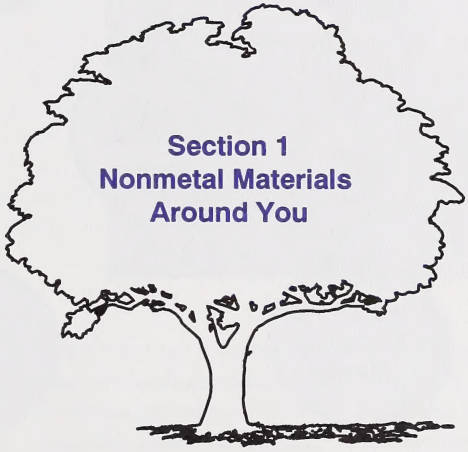
OVERVIEW

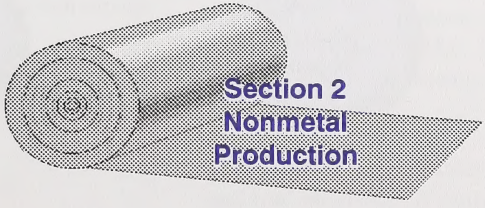
When you brushed your teeth this morning, did you think about what your toothbrush or toothpaste was made of? Can you think of ten nonmetal items that you encountered in the first half-hour of your morning? You may note such things as ceramic tiles in your bathroom, fabric in your clothing, or the plastic jug the orange juice came from. Nonmetals surround you all the time, and they play a big role in your life.

Module 5 concentrated on metal materials, their common applications, and related technology. In this module you will examine numerous nonmetal materials used in developing useful products like your toothbrush.

The properties and common applications of numerous nonmetal materials will be investigated and considered. You will also evaluate the impact of these materials on society and the environment.

Module 6
Exploring Nonmetals



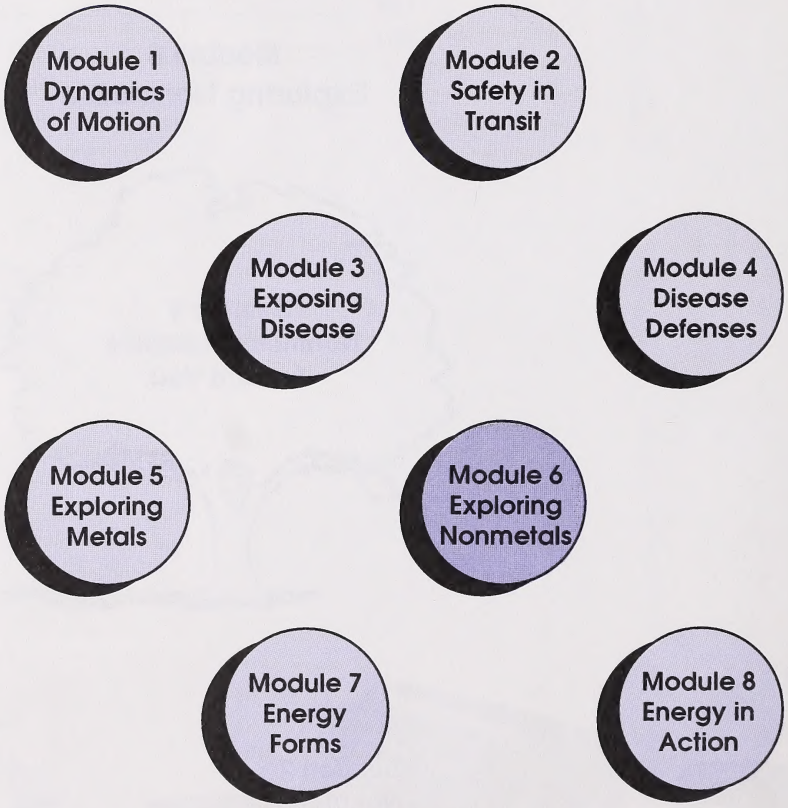


Evaluation

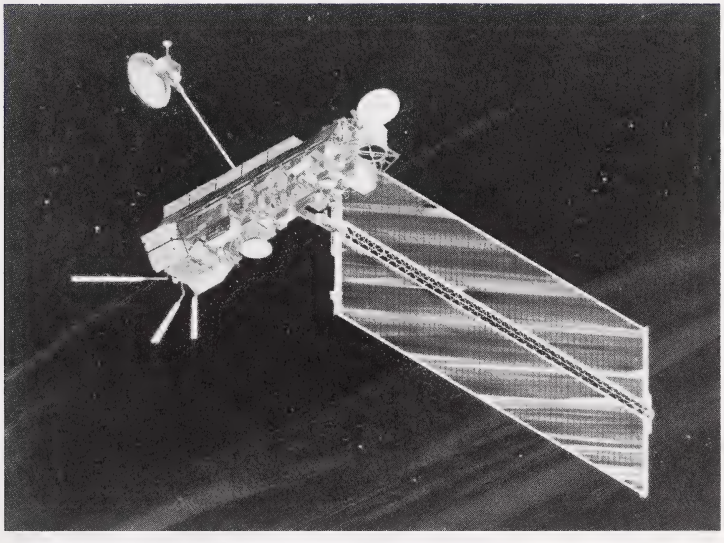
Your mark in this module will be determined by your work in the assignment booklet. You must complete all assignments. In this module you are expected to complete three section assignments. The mark distribution is as follows:

Section 1 Assignment	**24 marks**
Section 2 Assignment	**46 marks**
Section 3 Assignment	**30 marks**
TOTAL	**100 marks**

Course Overview



1 Nonmetal Materials Around You



NASA

What nonmetal materials have been developed during your lifetime for modern space technology and other uses? What are some of the common nonmetal materials around you? How many of these natural and man-made nonmetal materials could you identify? What are some properties that make certain nonmetal materials useful to their application?

Natural fibres such as wool, silk, linen, and cotton have been used for thousands of years. **Synthetic** rubber, plastics, pure silicon, fabrics, and other nonmetal materials have been recently developed for modern-day space technology and other uses.

In this section you will study how these nonmetal materials affect your lifestyle and how common they really are.

synthetic – a substance made by artificial means rather than through natural origin

Activity 1: Nonmetals in Your Life

Have you ever considered how your daily life has been affected by nonmetal materials? What products that resulted from material development required by space technology do you enjoy as a consumer?

The list of materials available to civilization continues to grow. Some may have even ended up in some of the products you enjoy. Can you think of such an example?

In order for technology to provide a wide variety of consumer products that everyone uses, materials must be available before they can be converted into useful items and devices.

1. Telecommunication systems have been and continue to be developed using fibre optics technology. Can you suggest two nonmetal materials used in making optical fibres?

   _____

   _____

However, new materials can also prompt the development of new products as uses for the new materials are found. For example, process cheese was introduced when a method of making a material from whey (a waste product of making cheese) was discovered. All of the possibilities for new materials are not yet known.

2. Synthetic rubber was systematically developed through the application of scientific processes to meet specific societal needs. Suggest why it replaced natural rubber.

   _____

   _____

Every product can be considered and evaluated in terms of its cost and benefits to society.

For example, the use of plastic materials in products has created a disposal problem that was not understood when the material was first introduced. Now that it is known that some plastics are not **biodegradable**, their environmental impact must be considered. This is a cost to society.

biodegradable – capable of breaking down a substance by the action of living organisms

3. What problems do plastic products create as solid wastes?

_____

_____

_____

4. Suggest some disposable plastic products that could be replaced with other materials to reduce solid waste problems.

_____

_____

_____

5. If plastic has created disposal problems, why has its use continued?

_____

_____

_____

6. What are some benefits that society gets from plastics?

_____

_____

_____

The impact of new materials on civilization was not fully understood until they were used for some time. When new materials become available they often replace old ones in the manufacturing of a product. For example, PVC (polyvinyl chloride) has partially replaced copper pipes in the water lines of a house. Plastic bottles have also replaced glass bottles.

7. Give a benefit of using plastic rather than copper for plumbing.

_____

_____

Check your answers by turning to the Appendix, Section 1: Activity 1.

Activity 2: Common Nonmetal Materials

You are surrounded with many common nonmetal materials. The only variation is in how these materials are used to make objects. The following photo has a combination of both metal and nonmetal materials.

1. List all the nonmetal materials you see in the photo.

   _____

   _____

   _____

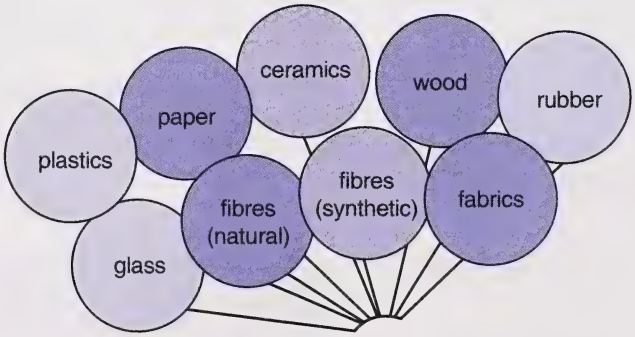
   _____

Alberta Agriculture, Information Service

Recall that a material is the substance from which a product is made. A material can be made of any substance or a mixture of substances. For example, glass used to make windows is primarily a compound of silicon and oxygen found in sand.

Concrete is a nonmetal material made from gravel, sand, and cement. It is therefore a mixture containing several materials in its composition.

Common nonmetal materials include the following:



2. Identify common objects made from each of the following listed materials. Suggest one reason why the material is used to make the objects that it does.

Material	Objects	Reason
metal	_____ _____	
plastic	_____ _____	
fibre	_____ _____	
fabric	_____ _____	
ceramics	_____ _____	
glass	_____ _____	
wood	_____ _____	
paper	_____ _____	
rubber	_____ _____	

Check your answer by turning to the Appendix, Section 1: Activity 2.

Follow-up Activities

If you had difficulty understanding the concepts in the activities of this section, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

To help you master the concept of common nonmetal materials, read the following information thoroughly.

- All things are made from common materials. A material is a substance from which something is made or can be made.
- Common materials from which things are made include metals, plastics, fabrics, ceramics, glass, and wood.
- Natural fibres include wool, silk, linen, and cotton.
- Synthetic or man-made fibres include nylon, polyester, rayon, and acetate.
- Plastic material waste does not decompose. It is a nonbiodegradable material.

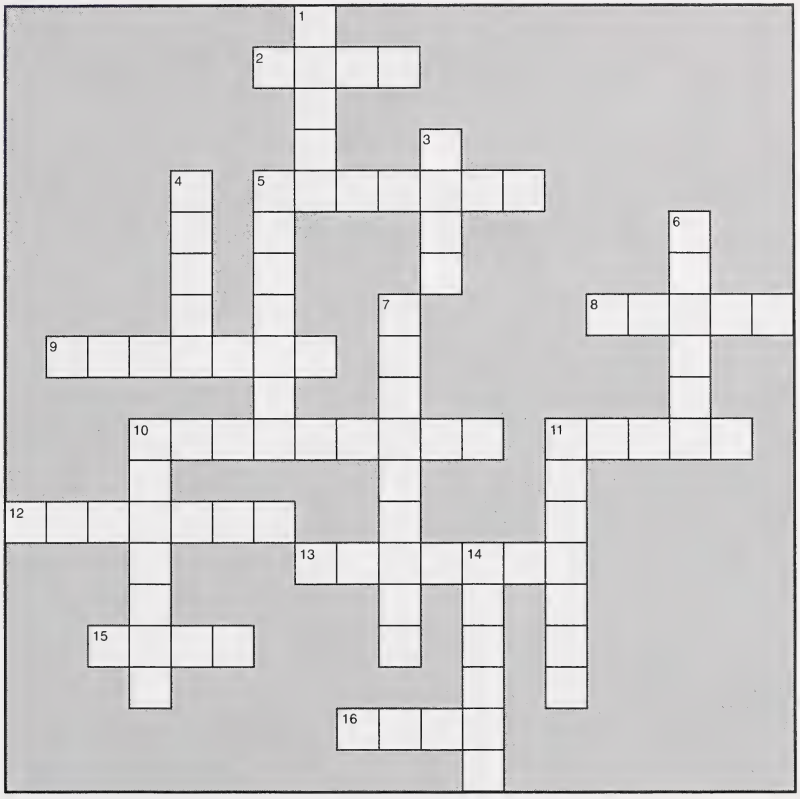
Complete the following nonmetal materials crossword.

Across Clues

2. polished grounded glass
5. layered wood
8. what silk is
9. plastic disc
10. blended with cotton
11. one of many in a fireplace
12. what some flower pots are made of
13. wool fibre
15. what some worms produce
16. braided sisal

Down Clues

1. antimony is one
3. tree product
4. optical lenses
5. baked clay
6. an example is denim
7. man-made
10. an example is a disposable spoon
11. inflatable rubber
14. tire



Check your answers by turning to the Appendix, Section 1: Extra Help.

Enrichment

1. Make a list of twenty nonmetal materials. Decide whether each material is synthetic or made from natural material.

2. Some of the nonmetal materials described in this section were available to the ancient Egyptians, and some nonmetal materials have only been recently developed. Research to find out whether the following materials are from ancient Egyptian times or modern times.

Check your answers by turning to the Appendix, Section 1: Enrichment.

Conclusion

Technology uses a wide variety of nonmetal materials to make items which consumers enjoy. Some of the nonmetal materials are found naturally and can be used directly. Others have to be modified or changed considerably from their natural source before they can become useful. It is because of their usefulness and properties that nonmetals are appreciated so much.

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 1.

2 Nonmetal Production

What paper products do you use in your daily life? Do you encounter a candy or gum wrapper, printed bus transfer, TV guide or other reading material, facial or toilet tissue, or notebook refill paper? How does the paper get from the tree to the paper you use? What other nonmetal materials are used in making your cassette tape, clothing, living-room carpet, or furniture upholstery? How are these nonmetal materials produced?

Some nonmetal materials can be obtained directly from natural sources. Others must be synthetically produced or indirectly obtained. For example, plastics are not found naturally. They require other sources such as petroleum to produce the plastic before it can be converted into items such as toothbrushes, combs, or calculators.

In this section you will be introduced to many nonmetal materials such as glass, wood, earth, fibers, fabrics, and plastics. You will also study how these materials are made into useful products.

Activity 1: Glass Material

Did you ever cut yourself on a piece of broken glass? When was the last time you looked at yourself in a mirror? Can you imagine yourself living in a house without windows? Glass material is everywhere around you.

Glass Material Applications



1. List twelve common objects that are made from glass material.

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

2. Suggest three advantages in using glass to make the objects that you just identified.

_____

_____

_____

3. Suggest three disadvantages in using glass to make certain products.

_____

_____

_____

When was glassmaking discovered? How is it made now?

It may surprise you that glass has been around for thousands of years. In Ancient Egypt, Syria, Phoenicia, and Persia, glass was used to make storage vessels.

During the Middle Ages, glass was so expensive that only the very wealthy could afford it.

Nobody would have considered using glass for windows as is done today. Light entered a house through holes in the roof or walls. Heavy shutters covered the holes during storms leaving the house in darkness.

Glass only became available for common use within the last 100 years or so.

4. What do you think was kept in glass vessels by wealthy people during ancient times and the Middle Ages?

_____

_____

5. Suggest two reasons why house windows were rarely used by early Canadian settlers.

_____

_____

To make glass now, silica is used. Silica comes from white sand. Most other sand contains impurities which discolour glass or change its hardness.

Other materials such as lime, soda ash, potash, lead, and borax are mixed with silica sand. The mixture is heated for several hours at extremely high temperatures in special furnaces until it melts.

Melted or molten glass is a very thick liquid. It is poured onto a cast iron surface to form a sheet. Asbestos-lined rollers flatten the liquid into glass sheets of various thicknesses.

When the glass plate is cooled, it is then polished and cut. To make safety windshields, a plastic sheet is sandwiched between two sheets of glass.

6. Suggest four factors that limit or prevent you from making your own glass windows.

_____

_____

_____

_____

Check your answers by turning to the Appendix, Section 2: Activity 1.

Have you ever seen a glassblower make ornaments in shopping malls, at trade shows, or at exhibitions? Glass can also be blown to create light bulbs and bottles, or it can be molded to form glassware. Glassblowing by hand is not as common since machines took over.

Did You Know?

In 1879 a dozen glassblowers were needed to produce 169 light bulbs for Thomas Edison in one day. Today, glass blowing machines can produce that same amount every minute.

Activity 2: Wood Products

WESTFILE INC.

You are reading words printed on paper. Look around right now – how many other things around you are made from wood products? How do trees end up as newspapers, magazines, and printed books? What material is commonly used for framing houses? How do trees turn into these everyday objects?

1. List four common uses of wood.

_____

_____

_____

_____

deciduous – trees or shrubs that shed their leaves annually

coniferous – cone-bearing trees that are mostly evergreen

Wood and wood products, such as paper, come from trees. Trees may be **deciduous** or **coniferous**. Wood from deciduous trees is generally hard. Soft wood is usually produced by coniferous trees.

2. a. List four common deciduous trees used to make wood products.

_____

_____

_____

b. List four common coniferous trees used to make wood products.

_____

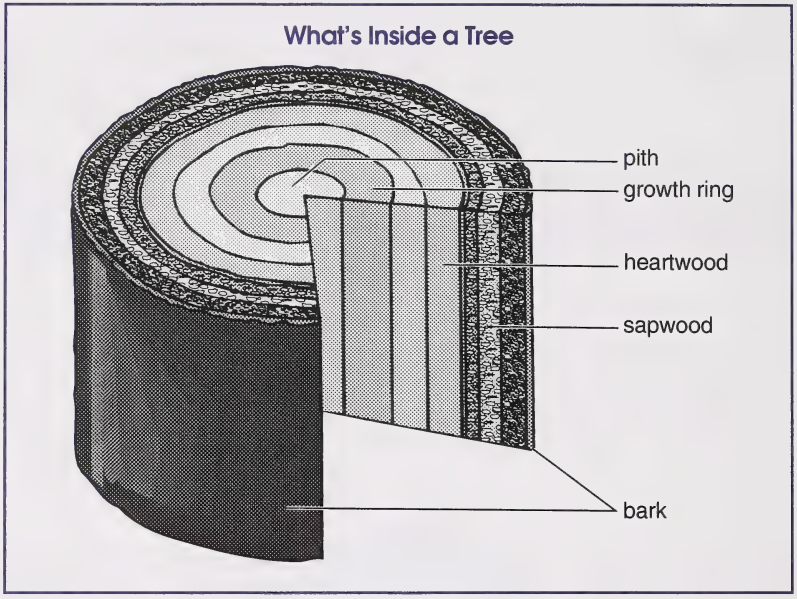
_____

_____

Did You Know?

The California redwoods are the oldest form of living things on Earth. Some trees are over 3000 years old and are large enough to drive a large car through.

Did you ever use wood to make a fire? Do you recall what the cut end of a log looks like? When the trunk of a tree is cut into slices, a section would look like the following diagram.



Bark is found on the outside layer of a tree. It protects the inside parts from injury and it is waterproof. The pith grows outward to produce bark and inward to produce wood.

heartwood – old growth rings of wood that are no longer alive and that are located towards the centre of a tree trunk

Growth rings can be found towards the centre of the tree. They can be counted to determine the age of the tree. The rings make up **heartwood**, which is no longer alive. This also makes the familiar wood grain pattern found in lumber.

sapwood – an inner layer of living cells, which contains sap inside conducting tubes, directly under the bark

Directly underneath the bark is **sapwood**. It is still alive and contains sap. Sapwood produces growth rings according to the growing conditions. In trees that are hundreds or thousands of years old, the growth rings indicate past weather conditions.

All green plants undergo the process of photosynthesis. You've studied photosynthesis before and you may recall that the word *photosynthesis* literally means *to make with light*.

3. What is the green material found in plants called?

4. What other materials are needed for photosynthesis to occur in green plants besides chlorophyll and sunlight?

_____

5. What materials do green plants produce during photosynthesis?

_____

The chemical change in photosynthesis can be represented by using the following word description: *Six molecules of carbon dioxide react with six water molecules in the presence of light and chlorophyll to produce one molecule of sugar and six molecules of oxygen.*

6. Using the word description, write the chemical change involved in photosynthesis in the form of an equation. Recall that the formula, $C_6H_{12}O_6$, is used to represent sugar in its simple form.

$$\text{\_\_\_\_\_} + \text{\_\_\_\_\_} \xrightarrow[\text{chlorophyll}]{\text{sunlight}} \text{\_\_\_\_\_} + \text{\_\_\_\_\_}$$

greenhouse effect – global warming resulting from solar energy trapped by the Earth's atmosphere

Photosynthesis is an important process because it removes CO_2 from the air. It also replaces O_2 that is needed to support animal and human life on Earth. When the levels of CO_2 in the air rise, the CO_2 traps heat from the sun to produce a **greenhouse effect**.

7. You may be aware that many people are concerned about the vast clearing of rain forests for agriculture. Why?

_____

_____

8. What can the lumbering industry do once the trees are cut down to produce wood products?

_____

_____

Check your answers by turning to the Appendix, Section 2: Activity 2.

Investigation: Inside a Tree

In this investigation you will use celery to get an idea of what goes on inside a living tree. It is difficult to view the inside of a tree.

Materials You Need

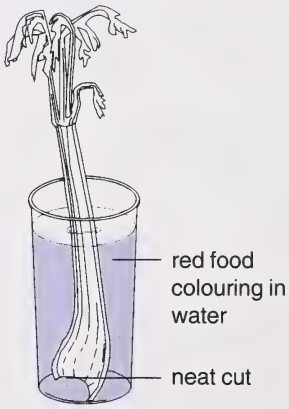
- a 20-cm stalk of celery
- 250 mL beaker or clear plastic cup
- red food colouring from your kitchen
- water
- sharp knife

Steps to Follow

STEP A

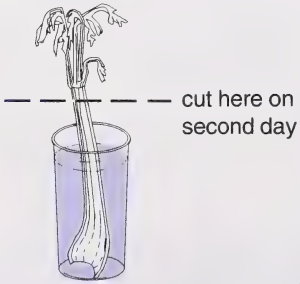
Fill a beaker or clear plastic cup with water. Add about 20 drops of red food colouring to the water.

Place the cut end of the celery stalk into the container. Make sure the bottom end of the celery is neatly cut.



STEP B

On the next day cut the stalk in half and observe the inside.



STEP C

Carefully take the celery stalk apart lengthwise. You should obtain celery strings running along the length of the stalk.

Observe the strings running along the length of the stalk.

Observations

9. Describe the cross section of the celery stalk cut after you remove it from the coloured water.

_____

_____

10. Observe and describe the strings along the length of the celery stalk once you separate them.

_____

_____

Conclusion

The coloured region consists of tubes or vascular tissue. These tubes conduct nutrients, water, and sap inside living plants including trees.

xylem – fibre tubes which form woody tissue inside plants

The tubes which allow movement of water and nutrients from the roots to the leaves is the **xylem**. The tubes that conduct soluble food manufactured in the leaves to other parts of the plant is the **phloem**.

phloem – conducting tubes inside plants through which food is distributed

11. Which part of a tree would probably contain vascular tubes?

_____

_____

12. Why does celery have a string-like structure?

_____

_____

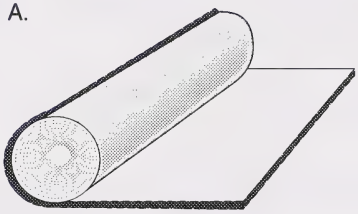
Check your answers by turning to the Appendix, Section 2: Activity 2.

Did You Know?

The most obvious use for trees includes lumber, paper, and plywood. However, maple syrup, turpentine, and natural rubber are also obtained from the sap of certain trees without destroying them.

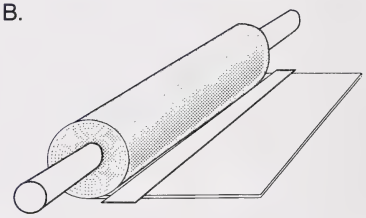
Plywood consists of thin layers of wood glued on top of each other. Its strength is increased by staggering the glued layers so that the grains lie across each other. The following is a simplified diagram for making plywood.

A.



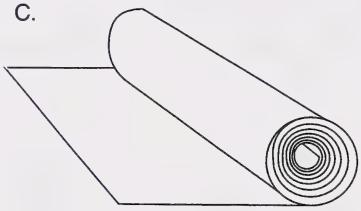
Bark is removed from a log.

B.



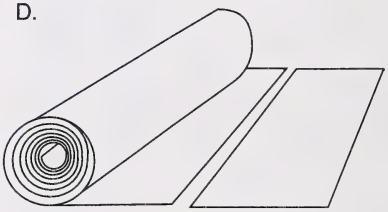
A knife cuts a thin layer from a centred and rotating log.

C.



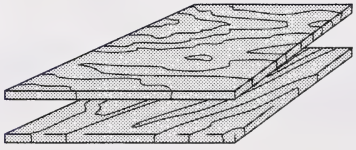
As the thin flexible sheet is cut, it is wound into a conventional roll.

D.



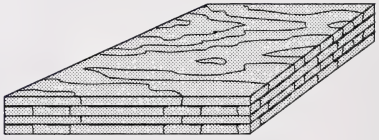
As the roll is unwound, a knife cuts the sheet into the size of a plywood layer.

E.



Cut sheets are stacked so that the wood grain runs in opposite directions.

F.



Sheets are then glued together in sufficient numbers to produce a required thickness of plywood.

13. Suggest three advantages in using plywood as a building material.

_____

_____

_____

Check your answers by turning to the Appendix, Section 2: Activity 2.

Activity 3: Paper Products

Can you imagine a world without newspapers, comic books, magazines, books, or cardboard boxes? Have you ever made a paper airplane? What is special about wood that makes it useful for so many products?

Did You Know?

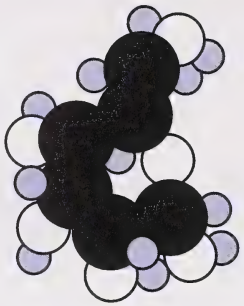
Paper towels were invented when a paper cutter failed to cut toilet paper into smaller rolls.

The following equation is given for photosynthesis occurring in green plants.

$$6\,CO_2 + 6\,H_2O \xrightarrow[\text{chlorophyll}]{\text{sunlight}} C_6H_{12}O_6 + 6\,O_2$$

The formula $C_6H_{12}O_6$ is used to represent sugar, starch, or cellulose in its simple form. What does a sugar molecule look like? The following diagram illustrates the structure of a sugar molecule.

Molecular Model of Sugar



monomer – one molecule which combines with other monomers to produce a polymer
Mono means one.

One molecule of sugar is called a **monomer**. The arrangement of many molecules of sugar bonded together to form a long molecule chain is called a **polymer**.

polymer – a large molecule chain made from many molecules
Poly means many.

1. Suggest what the word *polyester* could mean.

_____

_____

cellulose – long chained polymer found in cell walls of plants made from sugar molecules and used to make textiles and paper

When hundreds or even thousands of sugar molecules bond together to form a long molecule chain, the result is a substance called **cellulose**.

2. Explain how you would draw a cellulose molecule using the model of the sugar molecule.

_____

_____

Cellulose is common in many plants. It supports the plant in an upright position. It also makes up the tubes for conducting water and food within a plant.

corrugated – a honeycomb or wave-like layer of material to increase strength

Cellulose fibres from trees are turned into paper. Much like plywood, cardboard is made from thick layers of paper resembling a sandwich. The centre is reinforced with a **corrugated** core to increase its strength. You may have noticed its construction in a cardboard box.

3. Besides storage boxes, suggest six other cardboard products.

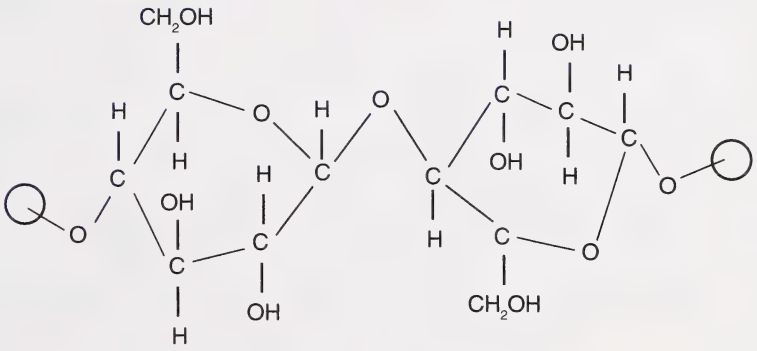
_____ _____

_____ _____

_____ _____

A cellulose molecule is given in the following illustration. Even though the molecule is very long, the simple sugar formula, $C_6H_{12}O_6$, is used to represent a cellulose molecule since sugar molecules are its building blocks.

Cellulose Molecule



Note: The circles mark the bond site where the next molecule will attach to form a long chain.

4. In what way is the cellulose molecule different from the sugar molecule?

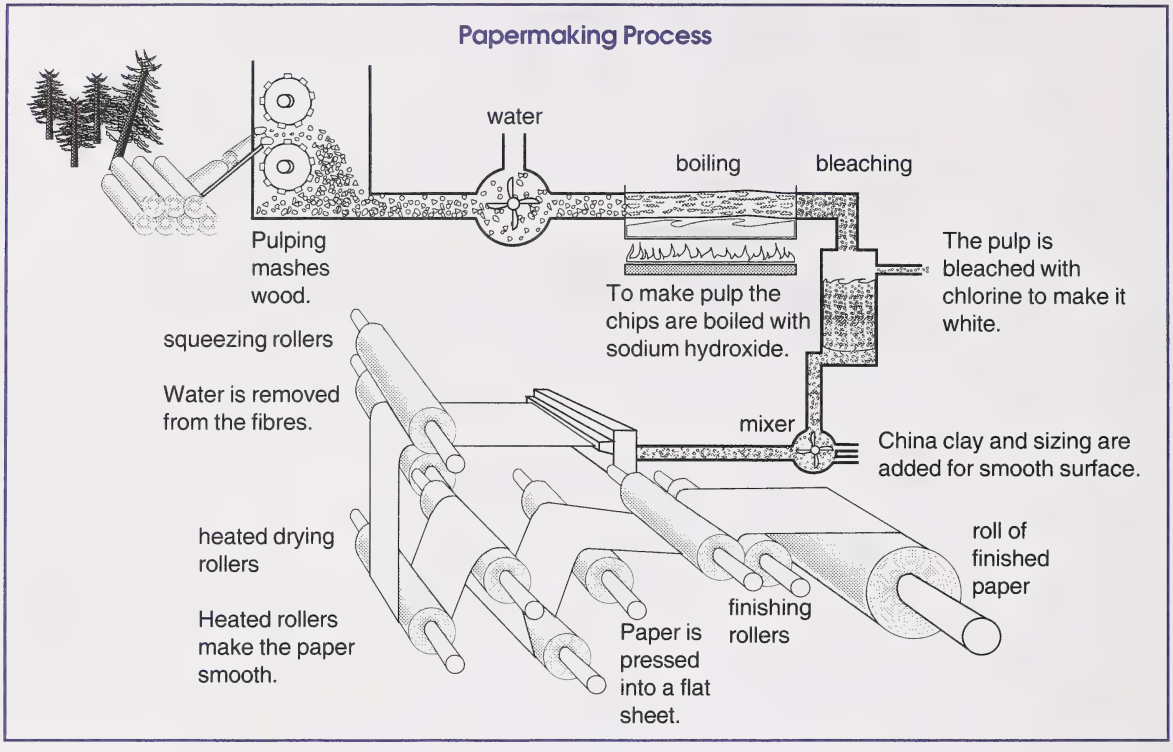
_____

_____

Although papermaking is more common now, paper has been in use for centuries. However, technology for making paper on a wide scale has only been developed within the last 100 years or so. Alberta has several pulp and paper mills.

Paper is so widely used in society that it accounts for most of the solid waste produced. How is paper made? What is involved in making paper?

The following steps show the process of making paper.



sizing – a pasty substance used as a glaze or filler on paper, cloth, or plaster

Paper is made by using many different fibres such as straw, flax, or softwood pulp. Wood pulp is made from ground up wood chips which are pressed into thick pulp sheets. In paper mills, the pulp sheets are shredded. They are mixed with waste paper, water, white clay, coloured dye, and **sizing**.

Excess water is removed as the pulp mixture passes through a series of rollers. Paper thickness can also be controlled during this process.

5. Outline the steps in the industrial papermaking process.

_____

_____

_____

_____

_____

Check your answers by turning to the Appendix, Section 2: Activity 3.

Activity 4: Earth Materials

Did you ever make mud pies? How does it feel to walk barefoot through a mud puddle?

Well, people have played with mud for a long time. Some Native American tribes even built clay houses. They learned how to use mud to make bricks and ceramics. They also learned to use other earth materials to make cement and concrete.

Concrete is a grey-coloured mixture of cement, water, and aggregate or crushed rock. A chemical change causes the mixture to harden or turn into a strong, durable solid.

1. Concrete is a widely used material. Suggest six structures in which concrete is used.

   _____ _____ _____

   _____ _____ _____

Did You Know?

Concrete can be coloured by the addition of chromium, cobalt, or iron oxides.

adhesive – a substance that joins or sticks to another substance

Concrete depends on cement, which has strong **adhesive** powers when combined with water. The cement is a fine flour-like powder that is made by pulverizing the raw materials used in making cement.

Oxides of calcium, aluminum, silicon, iron, and magnesium produce complex chemical changes when heated to make cement.

Besides concrete, bricks have been made by many civilizations for thousands of years. What is brick?

Brick is made from ordinary clay or shale and burned in kilns. Other material that can be added to the clay is cement and lime or an oxide of calcium. The raw materials are mixed with water to make a soft mud. The mixture is then molded into shapes, dried, and placed into kilns for baking.

2. When ancient civilizations made bricks, they baked them in the sun rather than kilns. What problems could be encountered by using this method?

_____

_____

3. Suggest four ancient civilizations that extensively used brick as a building material.

_____ _____

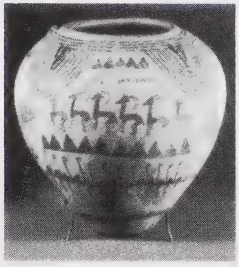
_____ _____

4. How are bricks held together to build structures?

_____

_____

Ceramic Material Applications



Quite often pieces of ancient pottery are the first thing that archeologists dig up in their search for understanding past civilizations. Man used clay for thousands of years to make pottery and cooking vessels. This pottery is known as ceramic.

Did You Know?

If you ever visit the ruins of Pompei in Italy, you will find ceramic tiles that were used inside the buildings before A.D. 79.

Ceramics are made from clay which is an abundant earth material mixed with water. The mixture can be shaped by hand, much like Plasticine, in a stationary position or on a revolving potter's wheel.

Clay can also be placed into molds of a desired shape or shaped by machines. Once the shape takes form, the object is baked in an oven or kiln. It becomes hard and fairly strong due to a chemical change that occurs.

Prior to baking or firing the object in an oven or kiln, colouring and glazing materials can be added. This process makes the object attractive, shiny, and waterproof.

5. Suggest four common ceramic products.

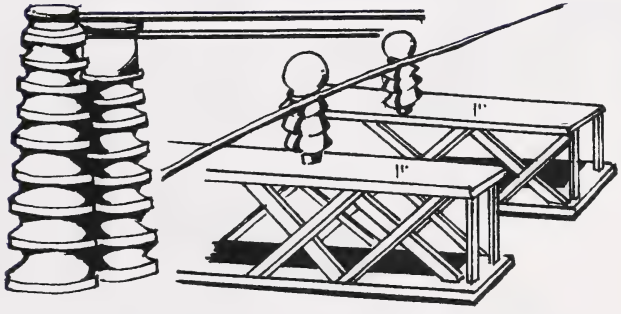
_____ _____

_____ _____

insulator – any material that is a poor conductor of electricity

Ceramic **insulators** are commonly found in electrical transformers and power transmission lines as shown in the following illustrations. The outer surface of a spark plug is also a ceramic insulator.

Ceramic Electrical Insulator



6. Why are power transmission lines connected to ceramic insulators?

_____

_____

Glazing the ceramic is necessary to make it waterproof, because ceramics made from fired clay are somewhat porous. Unglazed ceramics were used as early refrigerators because water slowly seeps out through the porous material. Wind evaporates the water that seeps out and makes the water inside cool even on a hot day.

Did You Know?

Ancient Greek sailors chilled their wine by storing it in ceramic pottery during their voyage at sea.

7. What cools the water inside a ceramic container?

_____

_____

8. During construction, ceramic weeping tile is installed around the basement of homes and is connected to a sewer line. Can you suggest why weeping tile is used?

_____

_____

9. Some people travelling in hot weather put a canvas bag of water on the outside of a car. How is the water inside the bag cooled?

_____

_____

10. Why does blowing on a spoonful of hot soup or hot chocolate cool it?

_____

_____

Porcelain is made from a white clay called kaolin. Expensive tableware china is a porcelain ceramic.

Bone china is also made from kaolin clay to which a powdered form of animal bone is added.

Did You Know?

Bones from North American buffaloes or bison were once used in making bone china.

11. Suggest two common porcelain products.

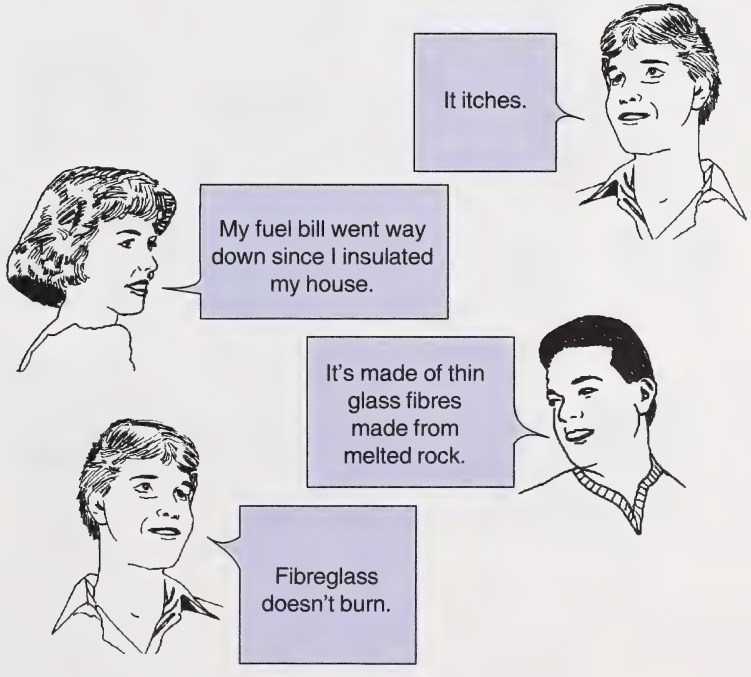
_____

_____

Check your answers by turning to the Appendix, Section 2: Activity 4.

Activity 5: Fibres

What do you know about fibreglass insulation? Perhaps the following dialogue may help.



molten – melted by heat

Recall that glass is made from sand. When it is melted at high temperatures, thin fibres are produced and intertwined to make the familiar insulation material. Only a few fibres, such as fibreglass, are made from **molten** material. However, all fibres are produced from solutions or fluids.

A fibre is a thin thread-like material. When a solution or fluid is forced through tiny holes in a machine, long thin fibres are produced once the liquid solidifies.

The fibres can be twisted into yarn from which fabrics and textiles can be made.

1. In what way is fibreglass similar to fabric?

_____

_____

_____

2. In what way is fibreglass different from fabric?

_____

_____

_____

Fibre optics were first discovered in 1955. In 1980 the technology was used to transmit local telephone signals. Long distance signals were transmitted in 1983. Signals were transmitted across the Atlantic Ocean in 1988 and across the Pacific Ocean in 1989. A fibre that is the thickness of a human hair can carry over 120 000 telephone signals.

Alberta Government Telephones now uses fibre optics cables rather than copper wire to transmit your telephone calls. In fact they were the first communications company to use this technology in North America.

You may have seen fibre optics light tubes used to produce illuminated coloured effects in advertising signs and displays. The technology is also widely used in probes to examine and view dark structures hidden inside the human body, sewer lines, and underground pipelines.

To explain fibre optics light tubes, the following dialogue may be helpful.

Fibre optics are made from extremely thin glass fibres about the thickness of a human hair.

Fibres are made in Saskatoon, Saskatchewan. Cables are assembled in Surrey, British Columbia.

A fibre optics light tube has about six fibres. Usually eight tubes are used to make a cable which contains forty-eight fibres.

Each fibre is covered with an acrylate plastic jacket. The tube containing six fibres takes as much space as two thin copper wires. The cable holding eight tubes is covered with a polyethelene plastic jacket.

Light travels along the fibres. Light is totally reflected internally as it glances off the walls. There is less heat energy given off than there is with an electric signal through copper wire.

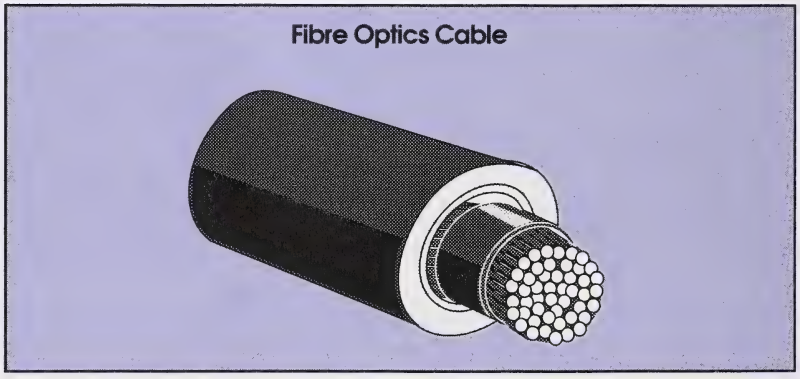
Transmission of light is not disturbed if the fibres or cable are bent. Light is transmitted along the bundle of fibres to the other end undisturbed.

It is used to transmit telephone calls and communication signals. It can also be used to make decorator lamps and illuminated water fountain streams.

Fibre optics are widely used in medicine for internal examination of organs. An endoscope can be inserted into internal organs such as the stomach. Light is sent through one set of fibres. Reflected light is transmitted back to a device which produces the image on a TV screen.

Greater details of an image can be obtained by using more fibres and thinner fibres.

The following illustration shows an example of a fibre optics cable containing forty-eight fibres. Its thickness is approximately similar to the lead inside your pencil.



3. Suggest why different coloured plastic jackets might be used to cover each individual optical fibre inside a cable.

4. If a break occurs in an optical fibre, it is spliced under a microscope with an electric spark. Suggest why this technique might be used.

_____

_____

Check your answers by turning to the Appendix, Section 2: Activity 5.

Activity 6: Fabrics

Classes of Fibres

Fibres such as silk, wool, cotton, or flax linen may come from natural sources. Natural fibres such as cotton or wool must be processed into fibres and then woven into fabrics.

Other fibres such as fibreglass, fibre optics, nylon, orlon, and polyester must be processed from other substances that are chemically obtained. These fibres are man-made or synthetically derived. Synthetic fibres do not exist naturally.

1. How are fibre materials classified?

_____

_____

The questions that follow will be based on the following reasons for developing and using synthetic fibres.

A. Synthetic materials are less expensive than naturally occurring materials used to make a product.

B. The supply of the naturally occurring material is exceeded by the demand for it.

C. Existing materials are unsuitable for making a new product, so a new material must be developed.

D. The synthetic materials were accidentally discovered. Often a use for the material is found after it has been developed.

2. For each statement select the most probable reason that explains why the material was developed. Place the letter(s) of the reason(s) in the space provided beside the statement.

a. _____ the development of synthetic rubber

b. _____ the development of Teflon

c. _____ the use of synthetic fabrics in clothing

d. _____ the use of nylon instead of silk

e. _____ the use of plastic pop bottles instead of glass

f. _____ the use of fibreglass insulation in homes instead of wood shavings

3. Indicate whether the following products are made of natural or synthetic materials. Use **N** for natural and **S** for synthetic.

a.	_____	rayon jacket	f.	_____	plastic bottles
b.	_____	orlon sweater	g.	_____	plywood
c.	_____	wool socks	h.	_____	fibreglass canoe
d.	_____	cotton pants	i.	_____	automobile tires
e.	_____	glass window	j.	_____	iron hammer

4. Why is paper not considered a synthetic material?

_____

_____

5. Suggest some reasons why synthetic fibres are replacing natural fibres on such a large scale?

_____

_____

6. What is one of the resources used to make synthetic fibres?

_____

Check your answers by turning to the Appendix, Section 2: Activity 6.

Blended Fibres

Do you prefer certain fibres or blended fabrics over others? What are blends? How can you tell if a fabric is blended?

blends – fabrics and other materials made from several other materials

Often it is beneficial to mix natural and synthetic fibres to produce a fabric that has properties of both fibres. Such fabrics are known as **blends**.

For example, cotton can be blended with other fibres, such as polyester, to improve the quality of the material. If clothing is made of both wool and polyester, the wool gives the fabric warmth and the polyester gives it strength and durability.

The content of the material is indicated on a tag on the article of clothing. It will indicate the percentage of each fibre in the article. For example, a shirt may be made of 65% polyester and 35% cotton.

There are many natural and synthetic fibres and fabrics. The following table lists some natural and synthetic fabrics and their properties.

Natural Fibres	Properties
wool	warm, resists wrinkling, dyes easily
cotton	cool, soft, dyes easily
Synthetic Fibres	**Properties**
acetate	dyes easily, shiny, strong
acrylic	dries rapidly, resists wrinkling
arnel	dyes easily, shiny, strong
dacron	washes easily, resists wrinkling, strong
dynel	washes easily, warm, resists mildew
nylon	tough, strong, elastic, resists mildew
orlon	dries rapidly, bulky
polyester	strong, resists wrinkling
rayon	dyes easily, shiny, strong

Use the information from the table to help you complete the following question. For each article in the chart, find the article in your household and look at the tag that describes the material of which the article is made. You may have to look at several articles of that particular type before a tag is found. Record this information.

7. Indicate whether the article is made of natural fibre (N), synthetic fibre (S), or a mixture of both (B) kinds of fibres in the following table. The first one is done as an example for you.

Article	Fabrics in Article	Type of Fabrics
T-shirt	cotton, polyester	B
sweater	_____	_____
towel	_____	_____
shirt	_____	_____
summer jacket	_____	_____
sweatshirt or sportswear	_____	_____
bathing suit	_____	_____
socks	_____	_____
a pair of pants or blue jeans	_____	_____
winter jacket	_____	_____

8. Why are natural and synthetic fibre blends beneficial?

_____

_____

_____

_____

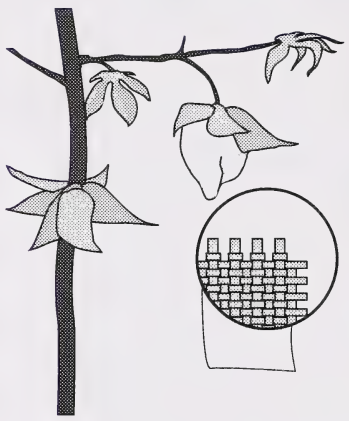
Check your answers by turning to the Appendix, Section 2: Activity 6.

Cotton Fibres

Do you have clothing that is made from cotton? What do you like or dislike about cotton fabrics? How is cotton produced?

Cotton is a natural fibre that grows on bushy plants in warm climates. When the cotton plant produces seeds, it forms seed pods called bolls. These pods ripen and burst open to scatter the enclosed seeds. Fluffy cotton fibres made of cellulose surrounding the seeds are collected from the open pod using a cotton gin.

Cotton Boll



Clusters of picked cotton fibres are torn apart by another machine. They are cleaned, straightened, carded, and made into sheets of cotton fibre or cotton wool.

Another machine pulls fibres from the cotton wool sheets to make thick strands or ropes and combs the sheets to remove short fibres.

Finally, a spinning machine twists the fibre into yarn which is woven into fabric. Clothing, bedding sheets, towels, and other cotton products can then be made.

9. Why isn't cotton grown in Alberta?

_____

_____

10. a. Suggest some advantages of using cotton cloth.

_____

_____

_____

_____

b. Suggest some disadvantages of using cotton cloth.

_____

_____

_____

_____

Check your answers by turning to the Appendix, Section 2: Activity 6.

Synthetic Fibres

Do you prefer clothing made from synthetic fibres rather than cotton or wool? Why are synthetic fibres used so extensively in the clothing industry?

11. Name some synthetic fibres.

_____

_____

Most synthetic fibres are produced by forcing a liquid substance through tiny holes in a metal disk to form fibres. These fibres are then woven into fabrics that are used to make clothing.

The properties of some synthetic fabrics make them useful for applications for which natural fibres are only marginally suited. For example, acrylic is a synthetic fabric that dries quickly; saran resists water. Natural fabrics do not have these properties.

Synthetic fibres tend to wash well and are durable, whereas natural fibres require more care during washing and are not as durable. However, natural fabrics have many desirable qualities. For example, cotton is comfortable and wool is warm. Natural fibres tend to collect less static charge and absorb moisture. Therefore, they tend to be more comfortable.

12. Which fabrics do you think tend to produce static cling?

_____

_____

Check your answers by turning to the Appendix, Section 2: Activity 6.

Rayon Fibres

Synthetic fibres are not found naturally. Some synthetic fibres, such as nylon and polyester, are actually plastics. They are man-made polymers. Recall that polymers are chains of monomer molecules.

However, rayon is not a plastic although it is still a polymer. It is made from cellulose and is one of the few synthetics made from natural material sources. Do you know how rayon is made or from what it is made?

Rayon is made by mixing cellulose fibres with sodium hydroxide, NaOH, and carbon disulphide, CS_2.

13. What are cellulose fibres made of?

_____

_____

14. What is the industrial source of cellulose fibres?

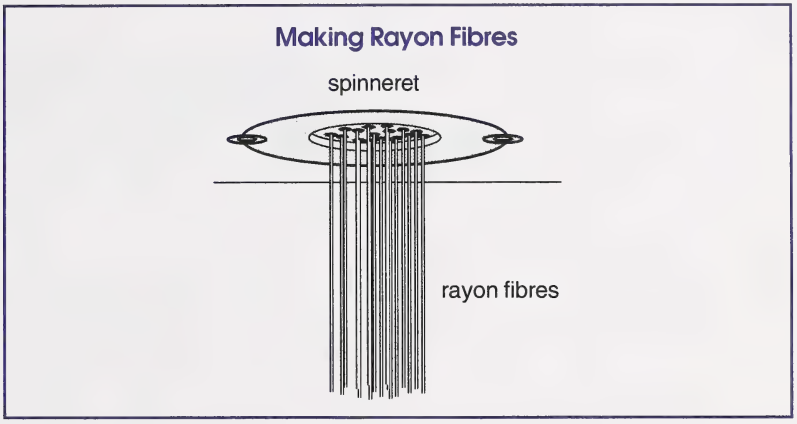
_____

_____

The process of making rayon is similar to making wood pulp. The solution containing cellulose fibres is agitated so that the fibres become separated into molecules. This mixture is then forced through a spinneret, a metal plate with holes in it, that creates thin streams of the solution.

The tiny streams fall into a dilute solution of sulphuric acid, H_2SO_4, where the threads solidify as rayon fibres. A spinneret can have 10 to 150 holes.

The following graphic illustrates the basic principle of making rayon. The width of the holes determines the width of the fibres. Finally, the rayon fibres are woven into rayon fabric which is used to make clothing.



Rayon was the first synthetic fibre made. It is called artificial silk because it is smooth, shiny, and feels like silk. Rayon fabric is strong, easily dyed, and its properties are suited for making clothing, curtains, and upholstery fabrics.

15. Nylon and rayon are both synthetic materials but are considerably different. Explain the difference.

_____

_____

_____

16. In the process of making a fibre, a spinneret is needed. Explain the function of a spinneret in making rayon.

_____

_____

_____

_____

17. What four properties make rayon a suitable material for making clothing?

_____

_____

_____

_____

Check your answers by turning to the Appendix, Section 2: Activity 6.

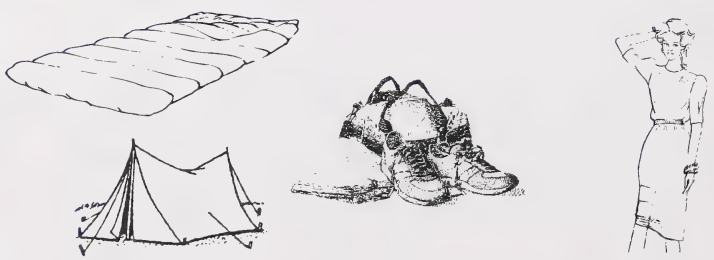
Nylon Fibres

Are you wearing an article of clothing made from nylon right now? Nylon was first introduced around 1935. It shared many characteristics with silk. When silk supplies from the Far East were cut off during World War II, nylon was extensively used for parachutes, ropes, and uniforms. Owning a pair of nylon stockings was a rarity. Now, nylon is common and you can probably see several things around you made of nylon.

Did You Know?

Do you know of the frustration of having a run in nylon stockings? Even though nylon runs in pantyhose or stockings are a nuisance, pantyhose is strong enough to tow a car or to make an emergency fan belt.

Nylon Material Applications



18. List four articles that are made from nylon.

_____

_____

_____

_____

Do you know how nylon is made or from what materials it is made?

Synthetic fibres can be made from either liquid organic compounds or natural cellulose. Organic compounds are molecules that are made of carbon. They may also contain hydrogen, nitrogen, sulphur, and oxygen atoms.

Nylon is one of the synthetic fibres made from liquid organic compounds. Most organic compounds are obtained from petroleum or natural gas. They are called **petrochemicals**. The petrochemicals used to make nylon fibres and many other products are referred to as **feedstock**.

petrochemical – an organic molecule obtained from petroleum or natural gas

feedstock – petrochemicals used to make specific fibres, plastics, and other organic substances

Nylon is made from substances derived from coal, oil, or natural gas. Petrochemical feedstock is commonly used to convert organic compounds into nylon involving a chemical change. It is made in a similar way to rayon except that cellulose is not used.

19. What advantage would there be in making nylon and other synthetic fibres in Alberta?

_____

_____

_____

_____

Nylon fibres are forced through a spinneret into an acid. The fibre threads are wound onto large reels as they form. They can then be woven into fabric.

Nylon fabric is strong, elastic, lightweight, shiny, very durable, and resistant to decay.

Did You Know?

A thread of nylon is 2000 times stronger than the same thickness of a thread of iron.

20. a. What are the advantages of using nylon as a material for clothing?

_____

_____

_____

b. What are the disadvantages of using nylon as a clothing material?

_____

_____

_____

Check your answers by turning to the Appendix, Section 2: Activity 6.

Activity 7: Common Plastics

Did you ever try to glue a broken plastic object? Did you succeed? Chances are that you were unsuccessful. You probably became frustrated and threw the broken object away.

1. What conclusions might you come to if you were unsuccessful in gluing a broken plastic object?

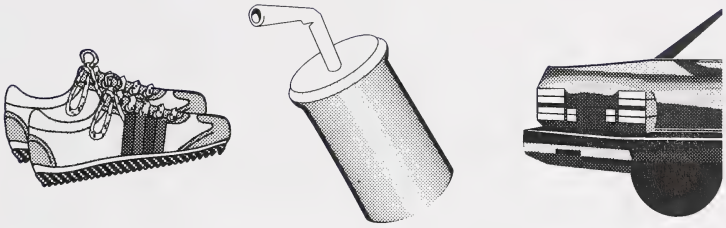
_____

_____

_____

There are more than fifty different kinds of plastics and thousands of variations. Each kind of plastic has its own unique properties. You would need to know the specific plastic used to make your broken object and its properties before you could repair the object.

Plastic Material Applications



Plastics are synthetic polymers involving complex organic molecules which chemists manufacture. Most are made from petrochemical feedstock. They are soft and can be molded at some time during their manufacture and formation into products.

2. Define the following words.

   a. organic

   _____

   _____

   b. polymer

   _____

   _____

   c. petrochemical

   _____

   _____

   d. feedstock

   _____

   _____

3. Name three resources found in Alberta that can be used to make plastics.

_____

_____

_____

As you think about all the products made from plastic, you may realize there are many different plastics and you might wonder how they are classified.

thermoplastic – a substance that becomes soft when heated and hard when cooled

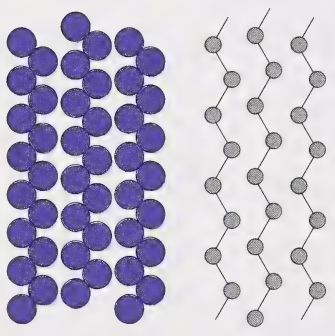
Plastics that become soft when heated or harden when cooled repeatedly are said to be **thermoplastics**. Alternate heating and cooling can reshape them many times.

thermosetting – setting into permanent shape when formed into products in molds

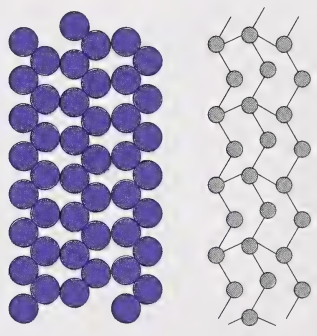
Plastics that are permanent cannot be changed back to their original fluid state. These plastics are **thermosetting**. It is similar to hard boiling an egg and trying to change it back to the original.

The structure of thermoplastics and thermosetting plastics is determined by the arrangement of molecules in the polymer chain as illustrated in the following graphic.

Thermoplastic and Thermosetting Molecular Structures



thermoplastic



thermosetting

Selected examples of common thermoplastic and thermosetting plastics, their properties, and applications are included in the following tables.

Thermosplastic Plastic	Property	Uses
ABS	strong, translucent	appliance housing, luggage, plumbing pipes and fittings
Acrylics	brittle, hard, many colours, transparent high gloss	aircraft safety glasses, model wax, salt and pepper shakers, taillight lens
Cellulosics	very strong, glossy, transparent, easily coloured	steering wheels, packaging, toys
Fluoroplastics	strong, waxy feel, translucent, chemical resistant	frying pan and other non-stick coatings, bearings, plumbing and electrical sealing tape
Phenolics	hard, brittle, rigid transparent, easily coloured	billiard balls, appliance handles
Polyesters	hard, strong, acid resistant	beverage containers, packaging, sporting goods, clothing, artificial limbs
Polyethylene	light, soft, feels waxy, transparent, flexible, moisture resistant, can be coloured	food containers, garbage bags, building construction, sheeting
Polystyrene	brittle, white, bend marks, glassy, transparent	blister packages, dishes, lenses
PVC – polyvinyl chloride	water, chemical, and weather resistant, flexible, glossy	washable wallpaper, handbags, rainwear, floor coverings, garden hoses, siding, eavestroughs, pipe and plumbing fittings

Thermosetting Plastic	Property	Uses
Epoxies	hard, transparent	metal to metal adhesive spray enamels
Melomines	very hard, scratch-resistant, good heat and electrical properties, many colours	dinnerware, kitchen counter and tabletops
Silicones	tough, hard, some flexible or rigid, opaque	putty, waterproofing, molds, caulking
Urethanes	mostly foams, flexible or rigid, opaque	cushions, sponges, insulation, shock and sound absorption

Use the plastics listed in the previous tables to answer the questions that follow.

4. Write the name of the plastic described in the statements.

   a. _____ a cookware coating that feels waxy

   b. _____ good weathering property; used for window glazing

   c. _____ made into pot and pan handles due to its high heat resistance

   d. _____ used to make molds for picture frames

   e. _____ used to make counter and tabletops

   f. _____ adhesive used to bond wood

   g. _____ thermosetting material made into dinnerware

   h. _____ soft, flexible, waxy-feeling plastic used to produce food containers, toys, grocery and garbage bags

   i. _____ made into taillight lenses

   j. _____ made into luggage and instrument panels

Did You Know?

Caesin plastic used for buttons, knitting needles, and umbrella handles is made from skimmed milk, a nonpetrochemical source.

Now that you are more familiar with the two types of plastics, you may be asking how plastic is made.

resin – a thick semi-solid substance obtained from certain plants and trees or made from synthetic materials which can become a plastic or other polymer

When plastic is first manufactured from its raw material, it could exist as powder, pellets, liquid **resin**, or fibres. These forms are then used to make various finished products. Many of these plastic raw materials are produced by the Alberta petrochemical industry. Why?

extrusion – forcing plastic material continuously through an opening

Some plastic products, such as the plastic coating on a pair of pliers, are made by **extrusion**. Other products, such as fibre optics cable and electrical wires, are coated with a thin film of plastic made by extrusion as well. A hot film of plastic is placed on the material and allowed to cool.

5. What are some uses for pipes and tubing made by extrusion?

_____

_____

6. Why are metals coated with plastic?

_____

_____

Did You Know?

Bread wrappers and food savers are a three-ply sandwich. A propylene plastic core and two thin outer layers of extrusion coatings of polyethelene are rolled together to form stretchable sheets.

The cap on a pen is usually made from plastic. The cap, like most plastic products, is made by using molds. This method repeatedly makes whatever shape is desired in a product. Hot plastics such as acrylics, silicones, and polyethylene are poured into molds and allowed to cool.

7. Why must the plastic be heated when placed into a mold?

_____

_____

Have you ever used fibreglass resin, hardener, and fibreglass fabric to repair a canoe or boat? Have you seen someone else do it?

catalyst – a substance that speeds up or slows down a chemical change but is not consumed or used up in the process

The hardener is a **catalyst** which hardens the resin into a plastic finished product by a chemical change. The catalyst only speeds up the chemical change, but it is not used up in the chemical change.

8. Fibreglass resin, hardener, and fibreglass fabric are used to repair minor dents and creases in auto bodies. What advantage does this method have?

_____

_____

Do you pack your groceries into plastic bags at a supermarket? Did you ever play with a plastic sand pail and shovel?

Polyethylene Applications

The plastic used to make food containers and squeezable shampoo bottles, ketchup bottles, and pop bottles is a polymer called polyethylene.

Natural gas is needed to make polyethylene. Natural gas is about 95% methane (CH_4), and 5% ethane (C_2H_6).

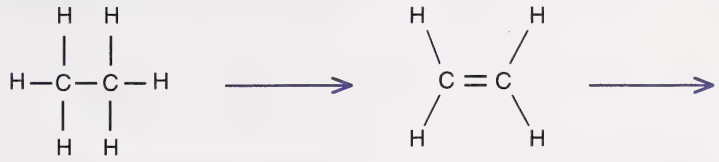
The ethane monomers are removed from natural gas and changed into ethene monomers, C_2H_4.

Thousands of ethene monomers are changed into a long chain of polymer molecules called polyethene or polyethylene as illustrated in the following graphic.

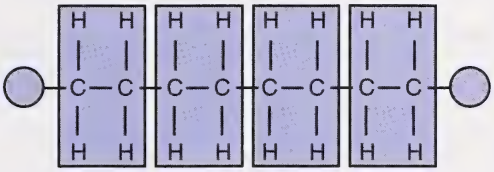
Formation of Polyethylene

ethane monomer in natural gas

ethene monomer forms a double bond



A polyethene polymer molecule is made from thousands of ethene monomers. The circle indicates the bond site where the next monomer will attach to make a long chain molecule. Note that only four monomers are illustrated in the polymer.



9. Polyethylene, also called polythene, is widely used as a vapour barrier sheeting in building construction. Why?

_____

_____

10. Give other uses for polyethylene sheets.

_____

_____

11. In what two ways does an ethene monomer molecule differ from an ethane monomer molecule?

_____

_____

12. Why are polyethylene pellets and products produced in Alberta?

_____

_____

Check your answers by turning to the Appendix, Section 2: Activity 7.

Follow-up Activities

If you had some difficulty understanding the concepts and the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

To help you master the concept of producing nonmetal materials, read the following information thoroughly. Complete the questions that follow the information.

- Glass is made from white sand.
- Wood, paper, and cellulose are made from trees.
- Cellulose is a polymer or long molecule chain containing many molecules or monomers.
- Clay and other earth materials are used to make ceramics, cement, and brick.
- Fibres are thin thread-like materials which may be natural or synthetic.
- Cellulose, cotton, and silk are examples of natural fibres, while nylon is an example of a synthetic fibre.
- Plastics are synthetic materials made from petrochemical feedstock.
- Thermoplastic plastics can be heated and cooled many times to change their shape.
- Thermosetting plastics are permanent once they are made into plastics.

1. Fill in the blanks.

   a. Glass can discolour or change its hardness if sand contains _____.

   b. Rollers used to flatten melted glass are lined with _____.

   c. When safety glass is made, the material sandwiched between the sheets of glass is _____.

   d. Trees producing hardwood are _____ trees.

   e. Trees producing softwood are _____ trees.

   f. The raw materials needed for photosynthesis are _____ and _____.

   g. The age of a tree can be determined by counting its _____.

   h. Because cellulose contains many molecules, it is a _____.

   i. Chlorine or hydrogen peroxide is used to _____ paper.

   j. Concrete is a mixture of _____, _____, and _____.

k. Bricks are made from _____ and baked in a _____.

l. Porcelain is made from a white clay called _____.

m. A fibre optics instrument used in medicine for internal examination is called an _____.

n. The first synthetic fibre ever made is called _____.

o. The word *poly* means _____.

p. Small repeating molecules that make plastic molecules are called _____.

q. Material that may be repeatedly softened when heated and hardened when cooled is _____.

r. A gas that is an important monomer for polyethylene is called _____.

s. Whether plastic is thermoplastic or thermosetting is determined by _____ _____.

t. A plastic that is resistant to heat and is used to make handles for pots and pans is _____.

2. Determine if the following statements are true or false. Write a T to indicate true and F to indicate false. Rewrite the false statements to make them true.

_____ a. Polyethene is a polymer made from natural gas.

_____

_____ b. Both natural and synthetic materials require processing.

_____

_____ c. Cotton is spun into yarn and then woven into fabric.

_____

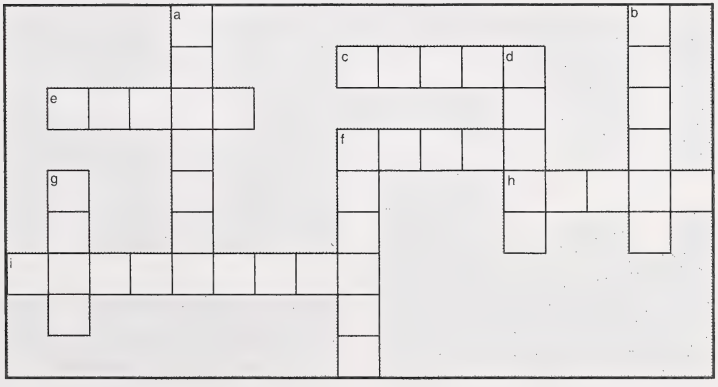
_____ d. Sizing and china clay are additives in the papermaking process.

_____

_____ e. A spinneret is used to mix solutions when making synthetic fibres.

_____

3. Using the following clues, complete the crossword puzzle on synthetic and natural fibres.



Across

c. artificial silk, made from cellulose
e. shiny, strong, dyes easily
f. washes easily, warm, resists mildew
h. dries rapidly, bulky
i. strong, resists wrinkling, used extensively

Down

a. dyes easily, shiny, strong
b. cool, soft, dyes easily
d. stockings made with this fibre
f. dries rapidly, strong, resists wrinkling
g. warm, resists wrinkling, dyes easily

Check your answers by turning to the Appendix, Section 2: Extra Help.

Enrichment

Do **one** of the following:

1. Write a report on why fibre optics are replacing copper wire to transmit communication signals.

2. Read the following sentences on the interaction between science, technology, and society. Answer the questions that follow.

    - Society, science, and technology are three factors that interact. They cause products and materials to change with time.

    - The relationship is complex. For example, scientists discovered a new semiconducting substance.

    - Technologists developed a method for producing the material and developed the microchip.

    - Society demanded quicker, more inexpensive, and more reliable computer systems that used less energy. An application for microchips was found.

    - Science asks *why*. Technology asks *how,* and society asks *should it be done*.

Complete the following statements by suggesting how either science, technology, or society issues are involved. An example is given.

Science asks: Why is ceramic material a suitable material for making toilet bowls?

Technology asks: How can toilet bowls be made efficiently and economically from ceramic materials?

Society asks: Should labour or machines or ceramic materials be used to make toilet bowls?

a. **Science asks:** Why does light travel through a glass fibre from one end to the other even if the glass fibre is bent?

Technology asks: How _____

_____

_____

Society asks: Should _____

_____

_____

b. **Science asks:** Why _____

_____

_____

Technology asks: How could you make paper from other cellulose sources besides trees?

Society asks: Could _____

_____

_____

c. **Science asks:** Why _____

_____

_____

Technology asks: How _____

_____

_____

Society asks: Should plastics be made from nonrenewable petrochemical resources if the products are difficult to recycle?

d. **Science asks:** Why _____

_____

_____

Technology asks: How _____

_____

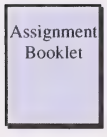
_____

Society asks: Should more money be spent on the research and development of natural and synthetic fibres?

Check your answers by turning to the Appendix, Section 2: Enrichment.

Conclusion

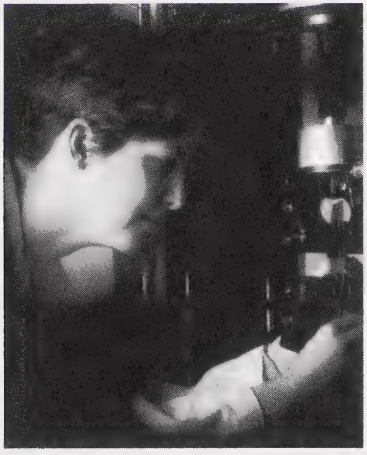
Nonmetal materials are natural or synthetic. They are common materials which are used to produce many objects in your everyday life. These materials need to be processed before technology can convert them into useful consumer products.



ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 2.

3 Investigating and Using Nonmetals



[1]

You have been introduced to many different kinds of nonmetal materials. Each type has its own properties that make it useful to make products with specific characteristics.

New technology and materials allow the development of new products to meet the demands of society. Materials and products are tested under laboratory conditions by industry before they reach consumers. Why?

In this section you will investigate some nonmetal materials properties. You will also be given additional examples of nonmetal uses. You will evaluate some nonmetal material applications that you find in your everyday life.

[1] *AT Plastics Inc.* for the photograph, taken from *The Intelligent Use of Technology*. Reprinted with permission of *AT Plastics Inc.*

Activity 1: Testing Nonmetal Properties

In Section 2 you learned about the properties of nonmetal materials. How could you test products made from glass? What wood, fibre, and plastic properties could be tested easily? Which materials properties would be difficult to test? Why?

1. What problems could you encounter with testing glass properties?

   _____

   _____

2. What problems could you encounter with testing wood properties?

   _____

   _____

3. What problems could you encounter with testing fibre and plastic properties?

   _____

   _____

Testing glass, wood, fibre, and plastic properties may require certain precautions or advanced laboratory equipment, devices, and instruments not readily available to you. However, industries involved in producing these materials are equipped with these advanced measurement devices to test the materials.

Your suggested materials testing will include properties that can be easily tested in a school laboratory. However they only represent a simplified sample of more complex testing done by industry.

For example, AT Plastics in Edmonton produces polyethylene pellets and products. Some of the testing done on polyethylene plastic includes

- molecular structure
- heating and cooling behaviour
- melt flow and elasticity
- tensile strength
- shrinkage, flexibility, and compression properties
- heat conductivity
- resistance to acids and other chemicals
- weathering resistance

4. Besides not having access to advanced laboratory equipment, devices, and instruments, what other limitations would you encounter in conducting some of the nonmetal properties testing?

_____

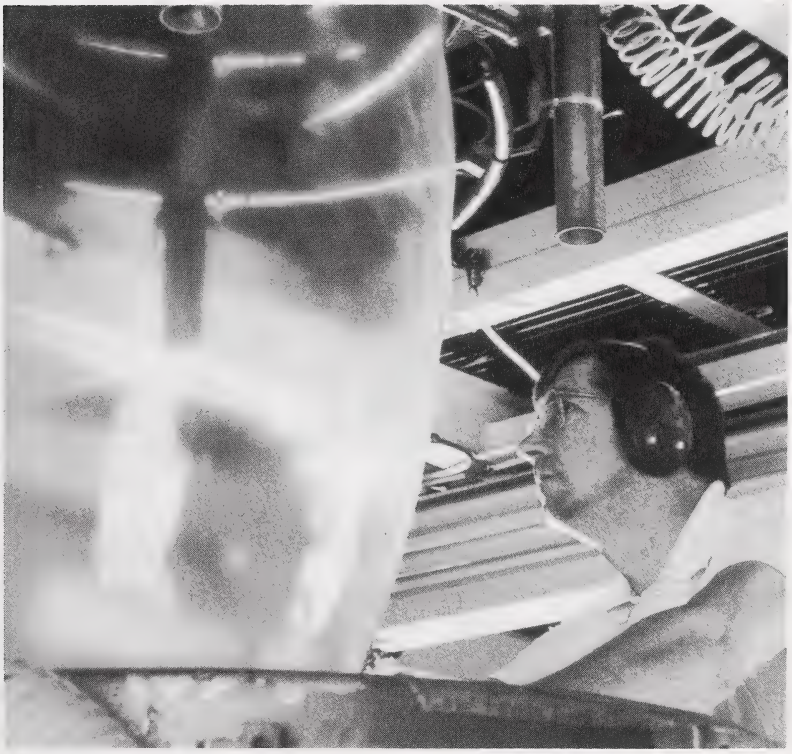
_____

_____

_____

Examples of equipment used to make such tests are illustrated in the following photo.

In the photo a technician checks copolymer film extrusion used to make cheese and meat packaging, athletic footwear, and carpet adhesives.



[1]

[1] *AT Plastics Inc.* for the photograph, taken from *The Intelligent Use of Technology*. Reprinted with permission of *AT Plastics Inc.*

Investigation: Making Paper

In this investigation you will make brown paper from pulp using shredded paper or white tissue paper.

Materials You Need

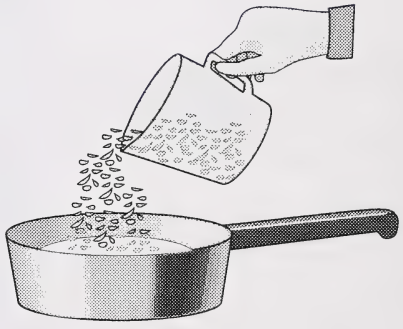
- box of facial tissue or shredded paper
- 2 L saucepan
- large mixing bowl
- blender or electric hand mixer
- sieve or strainer
- paper towels
- rolling pin
- discarded pantyhose
- coat hanger
- electric iron
- washing soda (sodium carbonate, Na_2CO_3)
- water
- two small squares of felt cloth about 30 cm × 30 cm

Steps to Follow

STEP A

To prepare the pulp, cut the shredded paper into 2-cm pieces, or tear the tissue into small pieces.

Half fill a saucepan or pot with the cut pieces of paper or tissue.



STEP B

Add 1 L of water and 250 mL of washing soda to the shredded paper or tissue and gently heat for 1 hour. Do not boil.

STEP C

Pour the mixture through the sieve.

STEP D

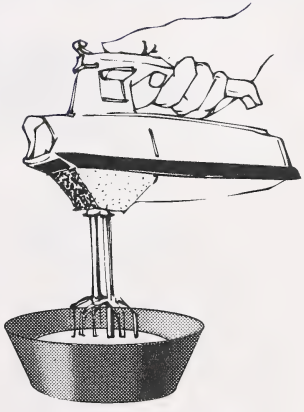
Rinse the mashed paper or tissue.

STEP E

Place the washed paper or tissue into a mixing bowl.

Add an equal amount of water.

Liquify or beat the mixture for about two minutes. The mixture should have the consistency of pancake batter.

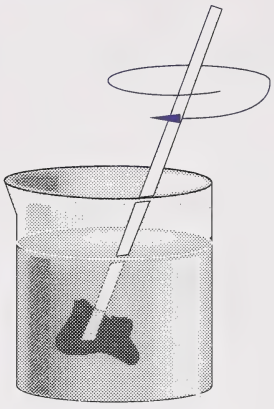


STEP F

Test the pulp by placing a drop into the beaker or cup filled with water.

The water should turn cloudy and no lumps should be present.

If this doesn't happen, beat the mixture for two more minutes and retest the pulp mixture.

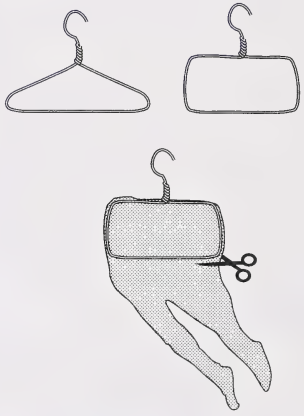


STEP G

Bend a clothes hanger into a small square and bend the hoop upward.

Insert the hanger into the pantyhose to make a tight fitting form.

Cut off any excess material.



STEP H

Place four paper towels on top of each other and arrange them on a table.

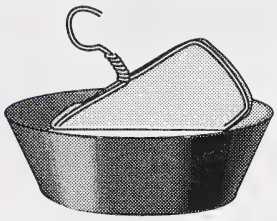
STEP I

Fill a bowl 3/4 full of water.

Add some pulp to the bowl and stir well.

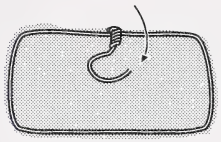
STEP J

Lower the hanger frame into the bowl, edge first, similar to putting a spoon into the bottom of a bowl of soup.



STEP K

Turn the hanger frame so that it lays flat on the bottom of the bowl.

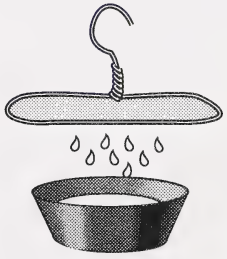


STEP L

Lift the hanger frame upward through the pulp.

Let the water drain off.

If the paper looks thin, add more pulp to the bowl and repeat steps J to L.

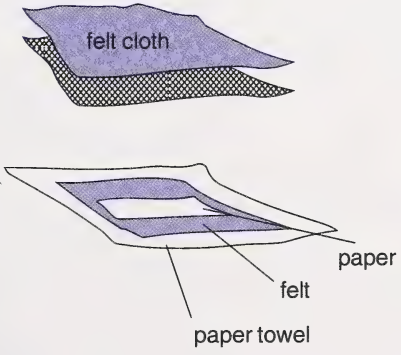


STEP M

Place a piece of damp felt cloth on top of the paper on the hanger frame.

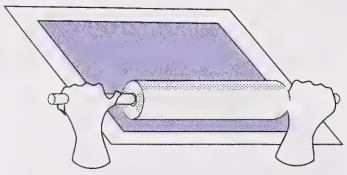
Carefully turn the hanger frame over the paper towel and remove the hanger frame.

Place another piece of damp felt cloth over the paper to make a paper sandwich.



STEP N

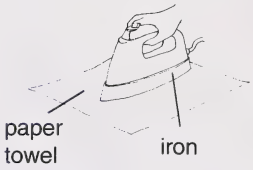
Roll the paper sandwich with a rolling pin.



STEP O

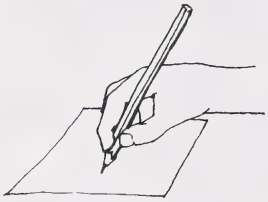
Remove the paper from the sandwich and place it between two paper towels.

Iron the paper until it is dry.



STEP P

You may now write on your paper with a pencil, ballpoint pen, or felt tip pen.



Observation

5. Write on your paper with a pencil, ballpoint pen, or felt tip pen.

   a. Which writing instrument works best? Why?

   _____

   _____

   b. Which of the three writing instruments is the least effective? Why?

   _____

   _____

Check your answers by turning to the Appendix, Section 3: Activity 1.

Investigation: Removing Stains

In this investigation you will stain four pieces of cotton fabric material and use several methods for removing the stain.

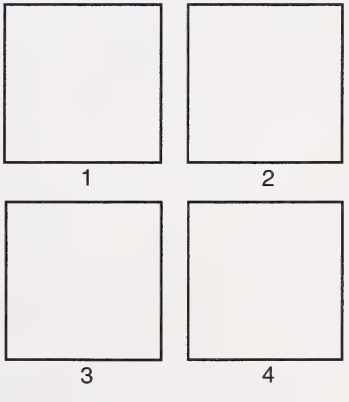
Materials You Need

- four pieces of 10 cm × 10 cm cotton material
- staining materials such as the following:
  - oil or grease
  - ink
  - blood from meat
  - coffee
  - nail polish
  - fruit juice
- four liquids for removing the stain
  - cold water
  - hot water
  - soapy water
  - rubbing alcohol
- four glass or plastic containers (beakers or bowls)
- tongs or tweezers
- scissors
- paper towel

Steps to Follow

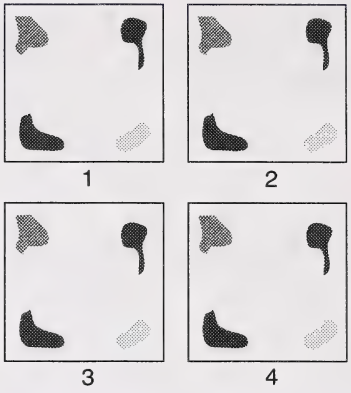
STEP A

Cut four pieces of cotton remnant material into 10 cm × 10 cm squares.



STEP B

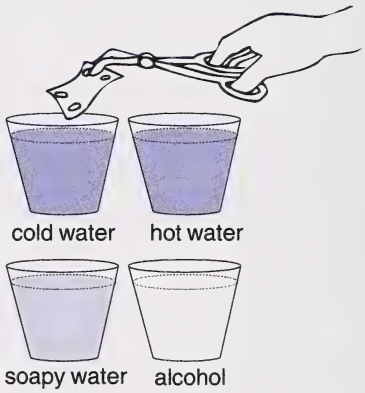
Select four stains that you will use. Stain each corner of the first square with a different stain. Repeat the same staining on the other squares.



STEP C

Fill one of the containers with cold water, one with hot water, one with hot soapy water, and one with rubbing alcohol.

Immerse each stained remnant with tongs or tweezers into the four different containers for one hour.



STEP D

Remove the treated pieces with tongs or tweezers and place them on paper towels.

Observation Table

6. Record your results by completing the following table. Record treatment success as (**X**-no ✔-yes)

Stain	Cold Water	Hot Water	Hot Soapy Water	Rubbing Alcohol

Conclusion

7. Suggest a suitable title for your table.

_____

8. Which stains were removed

   a. by cold water?

   _____

   b. by hot water?

   _____

   c. by hot soapy water?

   _____

   d. by rubbing alcohol?

   _____

9. Which stains were not removed by any of the treatments?

_____

_____

10. What is a stain?

_____

_____

11. Predict if the same tests would work with nylon.

_____

_____

What are your favourite clothing colours? Do you own clothing made from a colourful printed fabric? Did you ever experience a washload of fabrics that came out from the wash in a different colour than when they went in?

Dyeing is an important industry not only for fabrics but also for wood, paper, leather, plastics, and other materials. Your dentist may have even given you a disclosing tablet to dye the plaque on your teeth.

mordant – a substance that fixes a colour into a material during dyeing

colourfast – a material whose colour does not fade or run

Dyes are really like a permanent stain obtained from vegetable or chemical sources. The glue which sticks a dye to a fabric is called a **mordant**. If the dye remains on a fabric with repeated washing it is said to be **colourfast**. If it washes out it is not colourfast.

Did You Know?

At one time, most dyes were obtained from vegetable sources such as onion skin, red cabbage, or beets. Purple dye was obtained from the Murex shellfish by the Romans, Greeks, and Middle East civilizations. Purple became associated with royalty because only the wealthy could afford it.

12. Suggest why it is best to treat stains promptly.

_____

_____

_____

13. Suggest why fabrics should be tested for colourfastness before treating a stain.

_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 1.

Investigation: Fibre Burning

In this investigation you will identify different fabrics by burning their fibres. Make sure you do this investigation in a safe place. You may wish to do the investigation outside.

Materials You Need

- 1 cm × 1 cm pieces of fabrics such as cotton, wool, silk, nylon, polyester, acetate, or acrylic
- scissors
- binocular, low-power compound microscope, or magnifying glass
- four tin can lids or pieces of aluminum foil
- bunsen burner or lighter
- tongs

Steps to Follow

STEP A

Select at least five different types of fabric. Examine each fabric sample under a binocular or low-power compound microscope or a magnifying glass.

STEP B

Remove one fibre from each fabric and examine them under magnification. Make a sketch of the magnified fibres in the space provided.

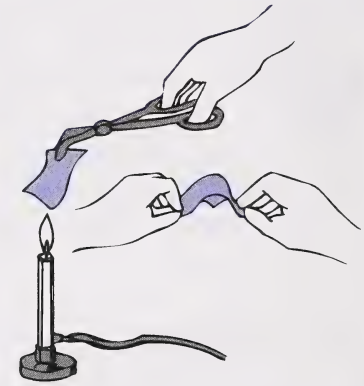
OBSERVATION

STEP C

Cut each fabric sample in half. Hold the first half of each fabric with tongs over a bunsen burner or lighter flame. Examine each burned fabric under magnification.

Try to bend or break each burned fabric.

Record your observations in the observation table.



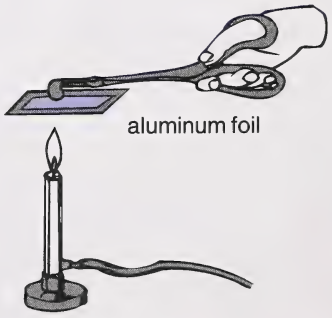
bunsen burner

STEP D

Place the second half of each fabric sample on a metal lid or on foil.

Hold the metal lid or foil with tongs over a bunsen burner or lighter flame.

Record your observations in the observation table.



aluminum foil

bunsen burner

Observations

Fabric name	Burn Rate (slow, fast, none)	Burn Colour (light, dark, black)	Burn Breakage (bends, snaps, none)	With Metal (melting, no melting)

Conclusion

14. Name three properties common to

    a. wool and silk fabrics

    _____

    _____

    b. cotton and silk fabrics

    _____

    _____

    c. polyester fabrics

    _____

    _____

    d. nylon fabrics

    _____

    _____

e. acrylic fabrics

_____

_____

15. What two properties are common to acetate fabrics?

_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 1.

Investigation: Dyeing Fabric

In this investigation you will tie-dye a fabric to produce a creative design or pattern.

Materials You Need

- any fabric that can be tie-dyed such as an old T-shirt
- a coloured dye purchased in drugstore, craftstore, etc.
- two large bowls or plastic pails such as ice cream pails
- three marbles or polystyrene balls
- water
- scissors
- paper towels or an old towel
- string
- tongs
- rubber bands
- rubber gloves

Steps to Follow

Note: When working with dye it is advisable that you wear the rubber gloves.

STEP A

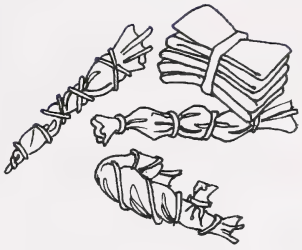
Mix the coloured dye inside a plastic pail according to the envelope instructions.

STEP B

Tie your fabric material using string or rubber bands in any of the methods shown or in your own creative manner.

You could insert marbles or polystyrene balls into your fabric when you tie it to produce various patterns.

You could also add wax patterns from a dripping candle prior to tie-dyeing your fabric. Wax resists dyeing to produce an effect called batik.



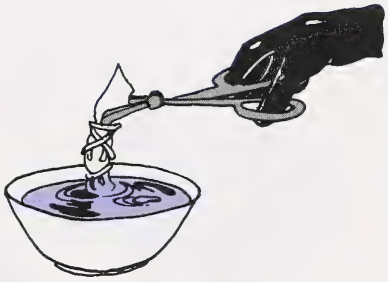
STEP C

Soak your tied fabric in cold water for about ten minutes.

Using tongs, place the tied fabric into the dye for about ten minutes.

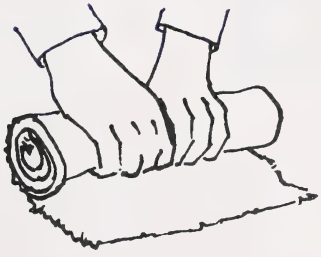
Remove the fabric from the dye.

Soak your fabric in cold water again for ten minutes.



STEP D

Remove your dyed fabric and spread it over two layers of paper towelling or over an old towel. Roll your fabric up and gently squeeze out excess dye. This should crack any wax if you made batik. Scrape any wax with a knife. Hang to dry.



Observations

16. Sketch a portion of the most interesting or pleasing pattern that you obtained in your fabric.

Conclusion

17. How does tie-dyeing a fabric produce patterned effects?

_____

_____

18. What is the difference between tie-dyeing and batik?

_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 1.

Investigation: Polymerizing

In this investigation you will simulate a polymer plastic or synthetic rubber by making a large polymer-like structure of long, chained molecules.

Materials You Need

- plastic bowl
- 250 mL cornstarch
- water
- mixing spoon
- food colour

Steps to Follow

STEP A

Mix 250 mL of cornstarch with 125 mL water in a plastic bowl. As you continue to mix, add water as needed to achieve a thick paste.

STEP B

Add about ten drops of food colour.

STEP C

Put your fingers or hand into the mixture slowly and observe your results.

Put your fingers or hand into the mixture quickly and observe your results.

Observations

19. a. How does the mixture react when your fingers or hand are placed into it quickly?

_____

_____

_____

b. How does the mixture react when your fingers or hand are placed into it slowly?

_____

_____

_____

20. How does the mixture react when you hit its surface?

_____

_____

_____

Conclusion

21. How do you know that the mixture is a polymer?

_____

_____

_____

22. In what way does the mixture behave as synthetic rubber?

_____

_____

_____

23. Suggest what the addition of food colour could illustrate or simulate.

_____

_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 1.

Activity 2: Common Nonmetal Uses

How many nonmetal product items could you name that you use on a daily basis?

Since a wide variety of nonmetal materials are available, their applications are so common that they are often taken for granted. Some product items are exclusively made from one type of nonmetal material only, while others are made by combining several nonmetal materials.

1. Suggest from what materials calculators or portable radios are made.

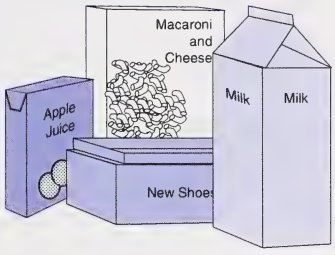
_____

_____

Paper Uses

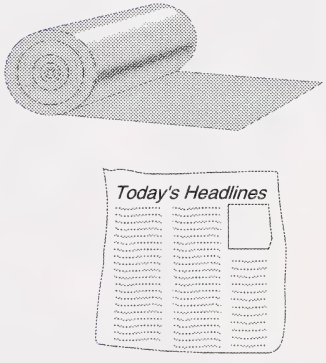
The following are examples of paper applications.

Cardboard



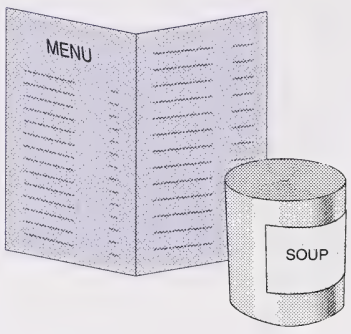
Cardboard containers and boxes are widely used as convenient food packaging. Large pieces of cardboard provide appliance protection and are also made into bulk storage boxes.

Newsprint



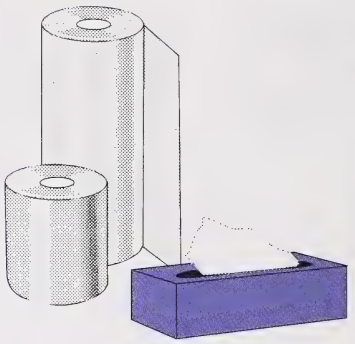
The largest user of paper is the newspaper industry. New York City uses as much newsprint in one day as all of Canada.

Shiny Paper



When paper is manufactured into rolls, it is first wound around a gigantic chromium-plated drum. When the paper is peeled from the drum it has a shiny surface and can be used to print restaurant menus and canned food labels.

Absorbent Paper



Size, which is a sealant, is added to paper during its manufacture to make it smooth and less absorbent. When less size is added, the paper is absorbent and used for making paper towels and toilet and facial tissue.

2. Suggest why paper products are so widely used.

_____

_____

3. What industry uses the most paper?

_____

4. What property of chromium-plating is used to produce shiny paper?

_____

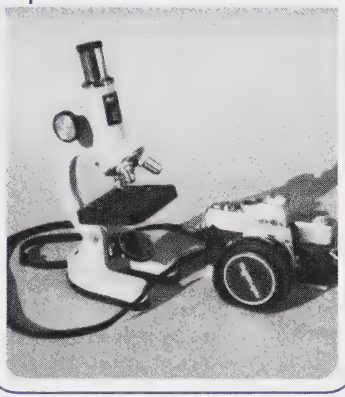
_____

Check your answers by turning to the Appendix, Section 2: Activity 2.

Glass Uses

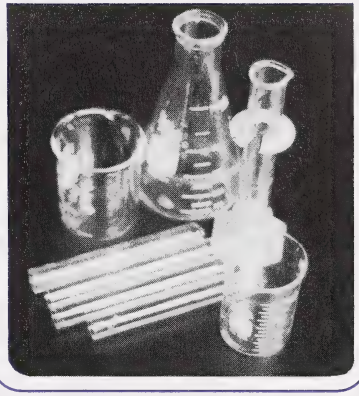
What do you feel when you enter a parked car that had its windows closed on a hot day? Did you realize that the glass windows were responsible for creating the unbearable heat in the car?

Optical Lenses



Curved glass in optical lenses bends light. This principle is used to magnify distant objects and those that are too small to be seen with the naked eye. Curved glass bottles can also start unwanted fires.

Labware



One desired property of lab glassware is that it should be transparent. It should have very little expansion when heated and little contraction when cooled. It should be washable and stain resistant so that it can be reused many times.

5. Suggest other objects in which glass lenses are used.

_____

_____

6. What are some uses of curved glass?

_____

_____

7. What is a likely source for curved glass that can start forest fires?

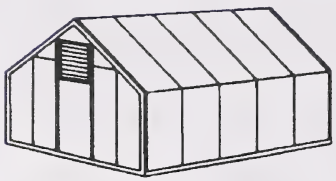
_____

_____

8. What is the name of the glass used to make labware such as beakers?

_____

Greenhouse Effect



greenhouse or solar heated house

Infrared radiation from sunlight can pass through glass without being absorbed. However, it is absorbed by air molecules in a greenhouse, solar house, or car with closed windows. Glass allows the heat rays from the sun to enter but not to escape. Therefore these structures become quite hot inside.

Coloured Glass

traffic lights

Oxides of different elements are used to produce coloured glass often seen in churches as stained glass windows. The following oxides make the respective colours: cobalt makes blue, manganese makes violet, gold or selenium makes red, uranium or silver makes yellow, and iron oxide makes brown.

9. If infrared radiation from the sun passes through glass, why does a greenhouse or car with its windows closed get hot?

_____

_____

_____

10. Suggest three uses for coloured glass.

_____

_____

_____

11. Which oxides are used to produce the following colours?

red _____ brown _____

violet _____ yellow _____

blue _____

Check your answers by turning to the Appendix, Section 2: Activity 2.

Fibre and Fabric Uses

Have you ever worn a snowmobile suit or ski jacket? What makes it warm during cold weather?

Clothes are designed to keep you warm during winter and cool during summer. Fabrics designed to keep you warm depend on the amount of air that is trapped inside the fibres. The more air that is trapped, the better the insulating property of the fabric.

12. During winter, birds fluff their feathers. How does this keep them warm?

_____

_____

_____

_____

13. Inuit wear loose clothing. How does this keep them warm?

_____

_____

_____

_____

14. Why is a woollen sweater warmer than a leather jacket?

_____

_____

15. When your body sweats, evaporation keeps you cool. Would it make sense to wear woollen clothing during summer? Explain.

_____

_____

_____

_____

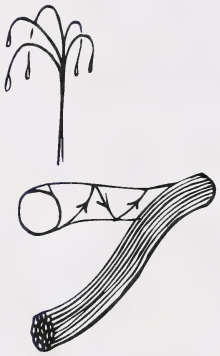
16. List some common items made from wool.

_____ _____

_____ _____

The following are examples of fibre and fabric uses.

Fibre Optics



A fibre optics decorator lamp emits light at the end of the fibres regardless of the bend in the cable. This is due to internal reflections of light waves in the fibre.

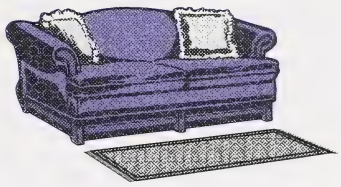
Fibre Fillers

Synthetic fibres are used as insulation fillers for sporting wear. The fibres are lightweight and provide comfort and warmth.

Canvas and Denim

Cotton fabric is available in a wide range of weights and textures. Denim is a durable fabric used to make jeans. Canvas is used to make tents, awnings, and tarpaulins.

Upholstery Textiles



A wide range of fibres end up in making consumer product items such as upholstery material, car seats, and carpeting material.

17. What material is used to make lightweight pup tents? Why?

_____

_____

_____

18. Why is nylon used in making sleeping bags and ski jackets?

_____

_____

19. Suggest three reasons why you would select synthetic fibres as insulation fillers in a jacket or ski suit.

_____

_____

_____

20. What fabrics can be made from cotton fibres?

_____

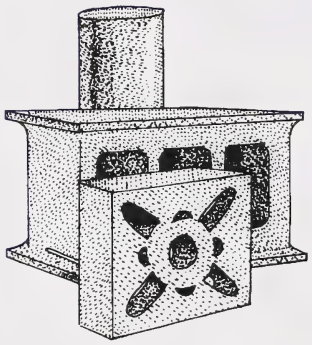
_____

Check your answers by turning to the Appendix, Section 2: Activity 2.

Earth Material Uses

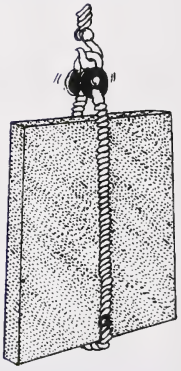
The following are products made from earth materials.

Concrete Products



Ready-made concrete is used for well casings, culverts, and sewer pipes. Blocks are used for building construction.

Precast Concrete



Large sections of precast concrete are used to build floors, walls, and supports in high-rise buildings, parkades, shopping malls, bridges, and other structures. The concrete is reinforced with iron rebar and could have embedded stones for appearance or effect.

21. What are the advantages of using precast concrete in building construction rather than pouring concrete into forms?

_____

_____

_____

_____

22. What is concrete cribbing and where is it used?

_____

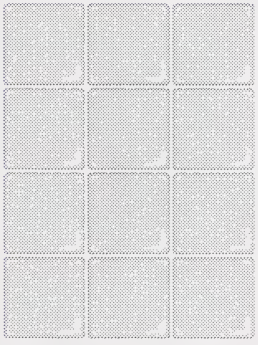
_____

23. What gives precast concrete its strength?

_____

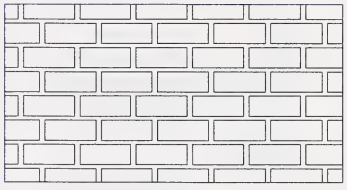
_____

Ceramic Tiles



Kitchen counters and bathrooms commonly use ceramic tiles. Ceramic tiled floors and walls are found in many public institutions and washrooms.

Brick



Bricks are a common building material for institutions. They are often used for planters, walkways, or fireplaces.

24. What are the advantages of using bricks to build schools, hospitals, and other large buildings?

_____

_____

25. Why are ceramic tiles used inside showers and on kitchen or bathroom counter backsplash areas?

_____

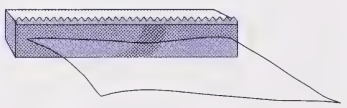
_____

Check your answers by turning to the Appendix, Section 2: Activity 2.

Plastic Uses

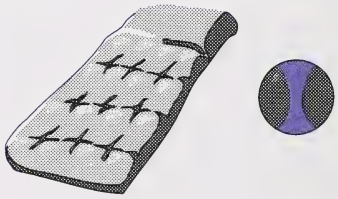
Some common plastic applications are illustrated in the following diagrams.

Stretchables



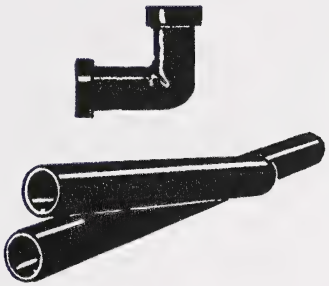
Stretch plastic, used to cover leftover food or to wrap sandwiches, is really a very thin three-ply sandwich itself. The centre is polypropylene with two thin extrusion coats on the upper and lower surface.

Inflatables



Inflatable beach balls and floatables are usually made from vinyl plastics.

Extrusion Products

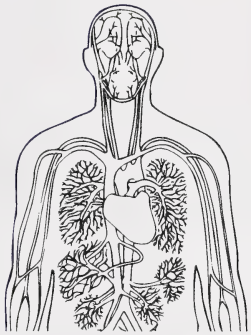


ABS (a very strong plastic) and PVC (polyvinyl chloride) plumbing pipes and connectors are produced by the extrusion process.

Polystyrene Insulation

Polystyrene insulation sheets are found in refrigerators, deep freezers, and camping coolers. Buildings are commonly insulated with polystyrene insulation. Polystyrene is also known by the trade name Styrofoam.

Models



Biological models of the human body and its parts are used in teaching. Other models such as mannequins and toys are also common.

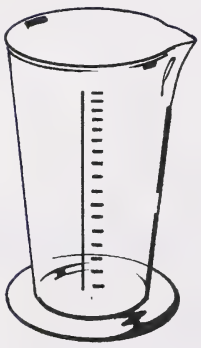
Squeeze Bottles

Squeeze bottles are used as convenient dispensers of shampoo, glue, oral hygiene products, and ketchup and other condiment food products.

26. What is an extrusion plastic?

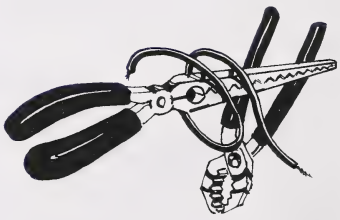
27. Discuss whether condiments and salad dressings should continue to be sold in convenient and disposable squeeze bottles or whether only refillable bottles should be used.

Labware



Polyethylene is a suitable material for laboratory "glassware." It is also widely used to make garbage bags.

Plastic Coating



Tool handles can be covered with PVC by dipping the tools into hot plastic.

28. a. Suggest why plastic should be used for garbage and grocery bags.

_____

_____

_____

b. Suggest why plastic should not be used for garbage and grocery bags.

_____

_____

_____

29. Why is polyethylene plastic used for labware?

_____

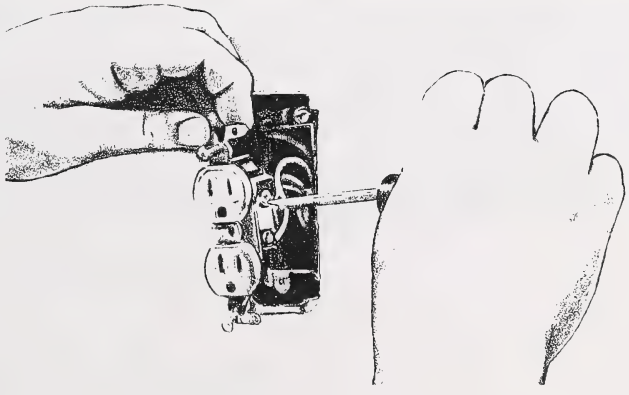
_____

30. Why are electrical tools and wires commonly covered with a plastic coating?

_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 2.



Activity 3: Biodegradable Versus Nonbiodegradable

Is garbage disposal one of your jobs at home?

How much paper, plastic containers, glass, and other nonmetal materials does your household generate in a week, month, or year? What happens to all the unwanted nonmetal materials?

Change Over Time

Could you name any products or items that did not exist when you were born? Are you aware of any products that were developed during your lifetime? What causes products and materials to change over time?

Products and materials change with time in response to the needs of society. Science makes new discoveries. Technology develops methods to apply these discoveries into materials and product applications. Introduction of new materials and products has an impact on the products or materials that they replace.

The following table lists some products and materials that have had an impact on other changes.

New Product	Old Product
synthetic fibres	natural fibres (cotton, wool, silk) and synthetic fibres based on cellulose (rayon, acetate, arnel)
plastics and aluminum	lumber and glass
detergents	soap
synthetic rubber	natural rubber
transistors	radio tubes
microchips	mechanical watches, adding machines, typewriters, copiers
aluminum and cement	steel
compact discs	phonograph records
inorganic nitrogen fertilizer	natural organic fertilizer
plastic plexiglass windows	glass windows
pesticides	natural predators
cars	mass transit and walking
telephone	telegraph
video machines	movie theatres

Experts predict that by the year 2000, synthetic material consumption will increase by over 400% from the 1990 consumption. The rapid increase in the use of new synthetic materials will replace many natural materials in the making of products.

1. a. Suggest why motor oil is now packaged in plastic containers rather than the former metal ones.

_____

_____

b. What problem do the empty plastic containers create that metal ones do not?

_____

_____

What eventually happens to fallen trees in a wooded area? What happens to fruit and vegetables that are several months old?

All biological or living organisms eventually decompose. Other living things use these decaying sources for food. The cycle keeps rotating.

decomposer – organisms that break down or biodegrade substances in the environment

Organic matter that decomposes is biodegradable. Organisms that decompose organic matter are **decomposers**.

producer – organism that can make its own food such as green plants

Green plants manufacture their own food through photosynthesis. They are called **producers**. Organisms that decompose plant materials are consumers, since they cannot make their own food.

enzyme – chemicals that act as catalysts in breaking the bonds between molecules and atoms but are not used up in the process

Atoms released in decomposition are reused many times when they are passed as food from producer to consumer. They are also released by decomposers when the producer or consumer is biodegraded. Decomposers biodegrade other organisms by using **enzymes** to break the bonds between atoms and molecules.

2. Why do decomposers require enzymes?

_____

_____

3. What three things are needed in order for garbage to decompose?

_____

_____

_____

4. What happens when garbage is decomposed?

_____

_____

_____

_____

Enzymes will only break down specific substances. For a substance to biodegrade in the environment, living things with enzymes that will break down the substance must be present. If these organisms are not present, then the substance will not biodegrade.

5. Suggest why many synthetic substances such as plastics are nonbiodegradable.

_____

_____

_____

_____

Nonbiodegradable materials persist in the environment and are difficult to dispose of. They tend to accumulate in the environment unless they can be recycled.

Solid waste material usually ends up in a sanitary landfill site. If the site contains only biodegradable materials, the waste will be broken down by decomposers. After the site is covered with soil, the area will return to its natural state.

If nonbiodegradable synthetic materials are present, they will remain. The site will not return to its natural state with these materials present.

6. What would happen to the environment if there were no decomposers?

_____

_____

_____

7. What happens to atoms when they are released from molecules?

_____

_____

_____

8. Often new synthetic materials replace natural ones. What are potential problems with this?

_____

_____

_____

9. Suggest several plastic products or uses which might be banned or discontinued in favour of other materials.

_____

_____

_____

_____

_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 3.

Follow-up Activities

If you had some difficulty understanding the concepts and the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

To help you master the concept of investigating and using nonmetal materials, read the following information thoroughly. Complete the questions that follow the information.

- Some nonmetal properties can be easily tested in a high school laboratory and some cannot.
- Industry is involved in nonmetal research and sophisticated testing of properties.
- Paper is used to make cardboard containers, newsprint, absorbent paper products, and paper for special purposes.
- Glass is used to make optical lenses, laboratory glassware, greenhouses, windows, and coloured glass.
- Fibres and fabrics are used to make fibre optics, insulating material, clothing, upholstery, and carpeting.
- Earth materials make concrete products, brick, and ceramics.
- Plastics make textiles, toys, food wrappers and containers, insulating materials, cushions, models, and extrusion products.
- Products and materials change over time.
- Materials that break down are biodegradable.
- Materials that do not break down are nonbiodegradable.
- Decomposers are organisms that break down materials using enzymes.
- Nonbiodegradable synthetic materials create disposal problems.

1. The following list of properties may or may not be present in certain materials. For each of the products given, write the letters of the properties that are present in the materials from which the product is made.

A. hard	D. elastic
B. tensile	E. conductive
C. flexible	F. transparent

a. _____ rubber tires

b. _____ house windows

c. _____ toy doll

d. _____ garden hose

e. _____ steel cable

f. _____ polystyrene cup

g. _____ denim blue jeans

h. _____ cardboard box

i. _____ brick planter

j. _____ cement sidewalk

2. Fill in the blanks.

a. The method used to remove blood stains from cotton fabric is to use _____ water.

b. Concrete is made by using _____, _____, and _____.

c. Iron rebar is used to _____ concrete.

d. The material used to seal the porous pulp used in making paper is called _____.

e. The largest user of paper is the _____ industry.

f. Shiny paper is made by winding paper onto large drums coated with _____.

g. Curved glass is used to make lenses because it is _____ and _____.

h. Glass used to make laboratory glassware is called _____.

i. To make red-coloured glass, an oxide of _____ or _____ is used.

j. A natural fibre that is used to make denim is _____.

k. One use for cement cribbing is _____.

l. ABS and PVC plumbing pipes and fixtures are made by the _____ process.

m. A plastic material used to make insulation sheets is _____.

n. Extrusion coatings are commonly applied to _____ and _____.

3. Determine if the statements are true or false. Write **T** to indicate true and **F** to indicate false. If a statement is false, rewrite it to make it true.

_____ a. All synthetics are nonbiodegradable.

_____

_____ b. The action of decomposers is the only process that breaks down materials in the environment.

_____

_____ c. New materials often replace old ones.

_____

_____ d. Animals are producers.

_____

_____ e. Decomposers use enzymes to break things down.

_____

_____ f. Atoms are not recycled.

_____

_____ g. Development and use of materials and products is dependent on the interaction of science, society, and technology.

_____

_____ h. An enzyme can break down many different substances.

_____

_____ i. A biodegradable substance can be decomposed by the action of organisms in the environment.

_____

_____ j. Chemical action is the primary way in which metals are broken down.

_____

_____ k. Everything is decomposed in a sanitary landfill.

_____

_____ 1. Recycling is a better disposal method for glass and for metals such as aluminum.

Check your answers by turning to the Appendix, Section 3: Extra Help.

Enrichment

1. Research and write a report on how to effectively manage solid waste.

2. Using ten items from the chart in Activity 3 on new and old products, decide whether the new products are more economical, more environmentally friendly, and more efficient.

Check your answers by turning to the Appendix, Section 3: Enrichment.

Conclusion

In this section you learned that nonmetal properties can be tested using simple or sophisticated equipment and techniques.

Nonmetal materials have a wide range of applications or uses from which society benefits. An undesirable effect of using these materials and products is the result of discarding them as waste once their usefulness is no longer required.

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 3.

MODULE SUMMARY

In this module you studied a variety of nonmetal materials – how they are produced and their uses in modern society.

You should have a clearer idea of the relationship between nonmetal materials and their applications.

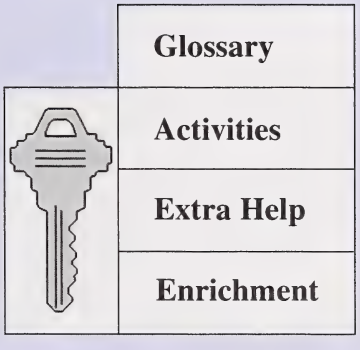
Nonmetal materials have specific properties due to their molecular structure. Materials for products are selected according to the suitability of the properties of the material for the product.

Materials used in society can be natural or synthetic. Both require processing in some manner before they can be used to make useful products.

You have studied how methods of producing and processing materials can be evaluated in terms of benefits to society as well as environmental concerns.

Finally, you've seen how some synthetic materials are not biodegradable because the enzymes required are not present in the decomposers. Recycling methods are preferable to their accumulation in the environment. In many instances recycling methods have yet to be developed.

Appendix



Glossary

adhesive
- a substance that joins or sticks to another substance

blends
- fabrics and other materials made from several other materials

biodegradable
- capable of breaking down a substance by the action of living organisms

catalyst
- a substance that speeds up or slows down a chemical change but is not consumed or used up in the process

cellulose
- long chained polymer found in cell walls of plants made from sugar molecules and used to make textiles and paper

colourfast
- a material whose colour does not fade or run

coniferous
- cone-bearing trees that are mostly evergreen

corrugated
- a honeycomb or wave-like layer of material to increase strength

deciduous
- trees or shrubs that shed their leaves annually

decomposer
- organisms that break down or biodegrade substances in the environment

enzyme
- chemicals that act as catalysts in breaking the bonds between molecules and atoms but are not used up in the process

extrusion
- forcing plastic material continuously through an opening

feedstock
- petrochemicals used to make specific fibres, plastics, and other organic substances

greenhouse effect
- global warming resulting from solar energy trapped by the Earth's atmosphere

heartwood
- old growth rings of wood that are no longer alive and that are located towards the centre of a tree trunk

insulator
- any material that is a poor conductor of electricity

molten
- melted by heat

monomer
- one molecule which combines with other monomers to produce a polymer
  Mono means one.

mordant	• a substance that fixes a colour into a material during dyeing
petrochemical	• an organic molecule obtained from petroleum or natural gas
phloem	• conducting tubes inside plants through which food is distributed
polymer	• a large molecule chain made from many molecules Poly means many.
producer	• organism that can make its own food such as green plants
resin	• thick semi-solid substance obtained from certain plants and trees or made from synthetic materials which can become a plastic or other polymer
sapwood	• an inner layer of living cells, which contains sap inside conducting tubes, directly under the bark
sizing	• a pasty substance used as a glaze or filler on paper, cloth, or plaster
synthetic	• a substance made by artificial means rather than through natural origin
thermoplastic	• a substance that becomes soft when heated and hard when cooled
thermosetting	• setting into permanent shape when formed into products in molds
xylem	• fibre tubes which form woody tissue inside plants

Suggested Answers

Section 1: Activity 1

1. Two nonmetal materials used in making fibre optics are glass fibres and plastic jackets or coverings.

2. Synthetic rubber replaced natural rubber as the demand was exceeding supply.

3. One problem created by plastic product solid wastes is its disposal. Many plastics are not biodegradable.

4. Some disposable plastic products that could be replaced with other materials to reduce solid waste problems could include polystyrene cups, plastic bags, and plastic containers.

5. The use of plastic has continued because plastic is an extremely useful and convenient material in many of the products people use.

6. Some benefits that society gets from plastics include the following:

    - Plastic replaces metals in many products, for example, plastic is used in prosthetic devices and body implants.
    - Cheaper products are available.
    - Durable products are available.

7. One benefit of using plastic rather than copper for plumbing is its resistance to corrosion.

Section 1: Activity 2

1. Answers may vary, but some nonmetal materials found in the photo include the following:

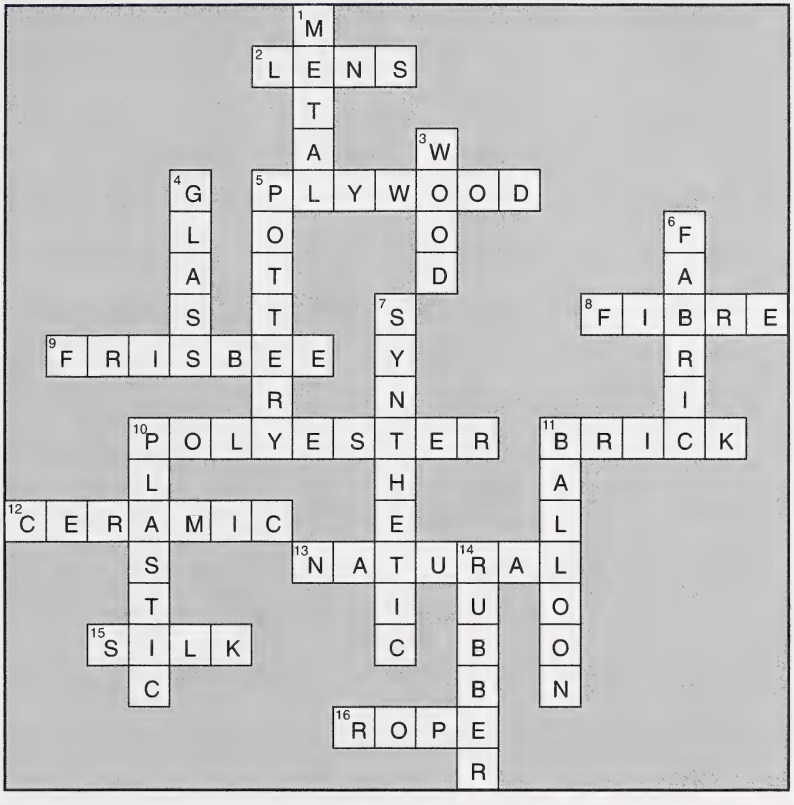
    - fabric
    - plastic
    - soil
    - rubber

2.

Material	Objects	Reason
metal	spoon nail barbed wire	hard, durable, strong
plastic	cups, cutlery grocery bag toothbrush	flexible, lightweight
fibre	fibreglass rope burlap	flexible, lightweight
fabric	drapes bed linen parachute	can be sewn, lightweight, resilient
ceramics	earthenware bathroom tile flower pot	strong, durable
glass	window light bulb bottles, jars	hard, smooth, transparent
wood	homes furniture boats	strong, can be cut and nailed
paper	cardboard box magazine receipt	can be printed
rubber	tire tube boots tubing	elastic

Section 1: Follow-up Activities

Extra Help



Enrichment

1. Answers may vary but could include:

Material	Egyptian Application	Modern Application
metal	gold jewellery	aluminum alloy shuttlecraft
plastic	not available	computer housing
synthetic fibre	not available	fibre optics
synthetic fabric	not available	astronaut space suit
natural fibre	ropes used to move stone blocks	chemical treatment for mildew resistance
ceramic	clay pottery, water jars	space shuttle, insulating tiles
glass	coloured glass vessels	computer screens
wood	wood ships and boats	plywood concrete forms
paper	papyrus scrolls	sticky memo pads
rubber	not available	spacecraft o-ring connections
brick	claybrick ovens	launching pad

2. A list of nonmetal materials and their classification as synthetic (S) or natural (N) could include the following:

- rayon – S
- silk – N
- cotton – N
- nylon – S
- fibreglass – S
- fibre optics – S
- rubber – N/S
- brick – N
- wool – N
- stainless steel – N
- plastic – S
- linen – N
- paper – N
- chalk – N
- orlon – S
- plywood – N
- glass – N
- polyester – S
- ceramic – N
- cement – N

Section 2: Activity 1

1. Common objects that are made from glass material could include:

- eyeglasses
- pop bottles
- camera
- street lights
- headlights
- windshields
- beakers
- microscopes
- jars
- light bulbs
- solar house
- water glass, pitcher

2. Advantages in using glass to make the objects that you just identified could include the following:

   - It is transparent.
   - It is smooth.
   - It can be sterilized.
   - It can be reused repeatedly.
   - It can be recycled.
   - It is available at a low cost.

3. Disadvantages in using glass to make certain products could include these facts

   - It is breakable.
   - It is hazardous when broken (unsafe).
   - It is heavier than plastic.
   - It ices up in cold weather.
   - It is nonbiodegradable.
   - It can act as a lens to start unwanted fires.

4. Glass vessels were probably used in the past to keep perfumes and spices.

5. The reasons why house windows were rarely used by early Canadian settlers are high costs, the use of native materials such as logs and stone, and scarcity of glass windows.

6. Some factors that would limit or prevent you from making your own glass windows could include sand impurities, improper mixture of other materials required, extremely high temperatures required to melt the mixture, the difficulty of forming sheets by pouring molten glass, and the skill required for cutting and polishing it.

Section 2: Activity 2

1. Common uses of wood could include the following:

   - telephone and electrical poles
   - pencils and rulers
   - railway ties
   - fences
   - bridges
   - farm buildings
   - furniture
   - boats
   - meat cutting board

2. a. Common deciduous trees include the following:

   - poplar
   - oak
   - ash
   - maple
   - birch
   - elm
   - walnut

   b. Common coniferous trees include the following:

   - spruce
   - fir
   - pine
   - hemlock
   - cedar
   - redwood

3. The green material found in plants is called chlorophyll.

4. Besides chlorophyll and sunlight the other materials that green plants need for photosynthesis are carbon dioxide, CO_2, and water, H_2O.

5. During photosynthesis green plants produce carbohydrates such as sugar, starch, and cellulose.

6. $6\,CO_2 + 6\,H_2O \xrightarrow[\text{chlorophyll}]{\text{sunlight}} C_6H_{12}O_6 + 6\,O_2$

7. Vast depletion of rain forests reduces oxygen supplies needed by humans and animals. It increases the amount of carbon dioxide which contributes to the greenhouse effect.

8. Reforestation or planting of trees is usually practised by the lumbering industry to replace those trees that have been cut.

9. Red circles should be evident on the bottom section of a cut celery stalk.

10. The strings along the length of the celery stalk should be coloured red.

11. The region directly under the bark or the sapwood contains vascular tubes.

12. Celery contains vascular tissue or bundles of xylem and phloem, which create a string-like structure.

13. Advantages in using plywood are its strength, convenient size, ease of handling, quick coverage of a large building or area, and decreased building costs.

Section 2: Activity 3

1. Polyester means *many ester* molecules.

2. A cellulose molecule drawing requires hundreds or thousands of identical linked sugar molecules.

3. Cardboard products besides storage boxes could include the following: milk and juice containers, textbook covers, poster paper, printed restaurant menus, corrugated packaging and shipping material for crated appliances, mailing tubes, and cylindrical concrete forms.

4. A cellulose molecule is hundreds or thousands of sugar molecules linked together. It is only different from a sugar molecule in size.

5. The steps for the industrial papermaking process include the following:

   - mashing the wood
   - making the pulp
   - bleaching the pulp
   - adding china clay and sizing
   - removing water from fibres
   - pressing the pulp into continuous sheets of smooth paper by rollers
   - drying the paper and putting it into huge rolls

Section 2: Activity 4

1. Structures in which concrete is used could include the following:

   - building blocks
   - basements
   - driveways
   - sidewalks
   - patios
   - bridge supports

2. Bricks that are baked in the sun rather than a kiln are not as weather-resistant and could fall apart from rain and other elements.

3. Some ancient civilizations that used bricks were the Greeks, Romans, Egyptians, Incas, and Mayas. They built roads (Apian Way), temples, pyramids, colosseums, and other buildings.

4. Bricks are held together with mortar which is a cement mixture.

5. Common ceramic products include vases, figurines, statues, pots, kilns, bake ovens, plaques, jewellery items, and tiles.

6. Power transmission lines are connected to ceramic insulators to prevent accidental electrocutions.

7. Because ceramic is porous, water seeps to the outside of the container. Here, evaporation takes place. The process of evaporation needs heat. It is a cooling process when heat is removed from the water inside the container.

8. Weeping tile collects excess rainwater and prevents it from entering the basement.

9. Evaporation of water on the outside of the bag increases in a moving car causing the water inside the canvas bag to cool since evaporation is a cooling process.

10. The wind you create speeds up evaporation of the hot liquid. Evaporation is a cooling process.

11. Common porcelain products include electrical insulators, light receptacles, dolls, figurines, sinks, bathtubs, toilet bowls, and fine china.

Section 2: Activity 5

1. Both fibreglass and fabrics are made from individual fibres that are intertwined.

2. Fibreglass is made from molten rock and fabric is made from other materials.

3. Each cable is made with several individual fibre optics inside it. A different coloured plastic jacket around each fibre optics would identify which fibre is inside which cable. Use of colour keeps track of which fibre is used for various communication signals.

4. Since fibre optics is a glass material, it needs to be melted by an electric spark. A microscope is used because it magnifies the hair-like fibre so that the splice can be accurately made.

Section 2: Activity 6

1. Fibre materials are classified as natural or synthetic.

2. a. B
   b. D
   c. A, B
   d. A
   e. A
   f. C

3. a. S
   b. S
   c. N
   d. N
   e. N
   f. S
   g. N
   h. S
   i. S
   j. N

4. Paper is not considered a synthetic material because it is made from the natural fibre cellulose.

5. Reasons why synthetic fibres are replacing natural fibres may include their strength, durability, resistance to shrinkage and wrinkling, ease of washing and dyeing, lower cost, and better availability.

6. One resource for making synthetic fibres is sand. Glass made from molten sand can be made into fibreglass and fibre optics.

7. Fabrics in the articles could vary but may include the following:

Article	Fabrics in Article	Type of Fabrics
T-shirt	cotton, polyester	B
sweater	cotton, wool, polyester, or mixture	N, S, B
towel	polyester and cotton	B
shirt	polyester or nylon	S
summer jacket	wool	N
sweatshirt or sportswear	polyester and cotton	B
bathing suit	polyester and cotton	B
socks	nylon, wool, cotton, or mixture	N, S, B
a pair of pants or blue jeans	wool, cotton, polyester or mixture	N, S, B
winter jacket	nylon or polyester with synthetic or natural fill	N, S, B

8. If the properties required by a product do not occur in one fabric, then the needs of the product might be met by mixing fibres. This provides properties of each fibre to the new material.

9. Cotton needs a tropical climate. The climate in Alberta is too cold for growing cotton.

10. a. Advantages of cotton clothing include the following:

- cool and lightweight
- dyes easily
- wide variety of weights and textures
- can be bleached

b. Disadvantages of cotton clothing include the following:

- creases readily
- subject to mildew and rot
- fades

11. Synthetic fibres could include rayon, nylon, acrilan, orlon, or polyester.

12. Some fabrics which tend to produce static cling could include nylon, polyesters, and orlon.

13. Cellulose fibres are made of chains of sugar molecules.

14. Cellulose is obtained from softwoods such as conifers.

15. Nylon is produced from synthetic fibres. Rayon is a synthetic that is produced from natural fibres.

16. A spinneret, which is a metal plate with holes in it, creates thin streams of a solution that solidifies as fibres.

17. Rayon is a suitable material for making clothing because it has the following characteristics:

- strong
- easily dyed
- smooth, shiny
- feels like silk
- static free
- absorbent
- doesn't fade

18. Nylon is a multipurpose fibre used to make ropes, jackets, carpeting, upholstery fabrics, shoes, tents, tarpaulins, tote bags, and luggage.

19. Alberta has abundant supplies of petrochemicals and feedstock needed to make nylon and other synthetic fibres.

20. a. The following are the advantages in using nylon. Nylon is

- resilient
- strong
- resistant to mildew and insect damage
- washes easily
- dries quickly
- blends with other fibres

b. These are disadvantages to using nylon:

- tends to yellow
- accumulates static electrical charges
- is a hot rather than cool fabric like cotton
- shags easily

Section 2: Activity 7

1. You might conclude that there are many different kinds of plastics, that the glue was not designed for the particular plastic, or that plastic cannot be repaired with glue.

2. a. Organic refers to molecules containing carbon.

   b. A polymer is a long chain of molecules containing many monomers.

   c. Petrochemical refers to a chemical derived from petroleum or natural gas.

   d. Feedstock is a petrochemical raw material used to make synthetics and other products.

3. Three Alberta resources that can be used to make plastics are coal, oil, and natural gas.

4. a. fluoroplastics
   b. silicons
   c. phenolics
   d. silicones
   e. melamines
   f. epoxy
   g. melamines
   h. polyethylene
   i. acrylics
   j. ABS

5. Some uses for pipes and tubing made by extrusion could include the following: water, sewer, and gas pipes; plumbing fittings; connectors; and hoses.

6. Metals are coated with plastic to prevent corrosion.

7. Plastic becomes semi-solid when heated and can be poured into a mold to assume the mold's shape.

8. Repairing minor dents and creases in auto bodies with fibreglass resin, hardener, and fibreglass fabric is effective, faster, and cheaper than repairing or replacing metal. It also will not rust.

9. Polyethylene is widely used as a vapour barrier sheeting in building construction to enclose the structure from rain and snow, especially during winter construction. It is also used as a vapour barrier between the insulation and plasterboard in homes.

10. Polyethylene sheets could be used as a vapour barrier in walls and floors of buildings and as a tarpaulin over haystacks, lumber, vehicles, machinery, and other outdoor items.

11. An ethene monomer molecule differs from an ethane monomer molecule in that it has a double bond between the carbon atoms and has two fewer hydrogen atoms.

12. Alberta has an abundant supply of natural gas needed to produce polyethylene.

Section 2: Follow-up Activities

Extra Help

1. a. Glass can discolour or change its hardness if sand contains **impurities**.

   b. Rollers used to flatten melted glass are lined with **asbestos**.

   c. When safety glass is made, the material sandwiched between the sheets of glass is **plastic**.

   d. Trees producing hardwood are **deciduous** trees.

   e. Trees producing softwood are **coniferous** trees.

   f. The raw materials needed for photosynthesis are **water** and **carbon dioxide**.

   g. The age of a tree can be determined by counting its **rings**.

   h. Because cellulose contains many molecules, it is a **polymer**.

   i. Chlorine or hydrogen peroxide is used to **bleach** paper.

   j. Concrete is a mixture of **cement**, **water**, and **aggregate**.

   k. Bricks are made from **clay** and baked in a **kiln**.

   l. Porcelain is made from a white clay called **kaolin**.

   m. A fibre optics instrument used in medicine for internal examination is called an **endoscope**.

   n. The first synthetic fibre ever made is called **rayon**.

   o. The word *poly* means **many**.

   p. Small repeating molecules that make plastic molecules are called **monomers**.

   q. Material that may be repeatedly softened when heated and hardened when cooled is **thermoplastic**.

   r. A gas that is an important monomer for polyethylene is called **ethane**.

   s. Whether plastic is thermoplastic or thermosetting is determined by **molecule arrangement**.

   t. A plastic that is resistant to heat and is used to make handles for pots and pans is **acrylic**.

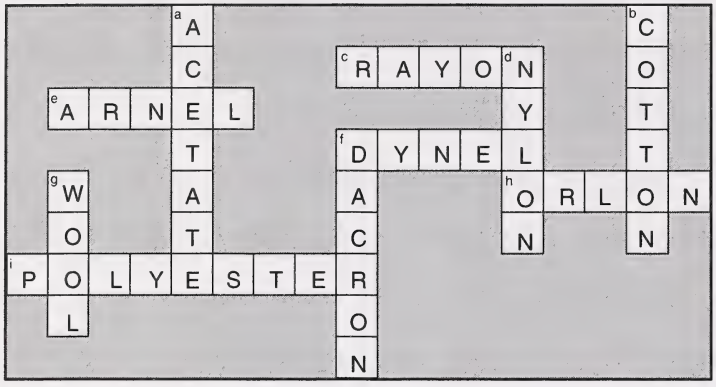
2. a. **T**

   b. **T**

   c. **T**

   d. **T**

   e. **F** A spinneret creates thin streams or fibres of synthetics.

3. 

Enrichment

1. Answers could vary but could include some or all of the following reasons:

   - Fibre optics increase the distance in which repeater stations are placed – every seventy kilometres for telephone signals or about every one kilometre for TV cables with copper wire. As distance increases, communication signals become weaker and must be boosted with repeaters.

   - Fibre optics increase the potential band width which determines the amount of information that can be transmitted.

   - Fibre optics are smaller, lightweight, and they can fit in tighter spaces than copper wire.

   - Fibre optics reduce security risks because communication signals such as those involving computers are more difficult to tap into.

   - Fibre optics do not pick up electrical interference in areas of high electrical activity as does copper; therefore signals are clearer.

   - Lightning does not strike the nonmetal fibre optics.

2. Answers may vary but could include the following ideas:

   a. How could you find a better material for light to pass through?

      Should materials that are difficult to recycle be continued to be used?

   b. Why do coniferous trees make the best cellulose fibre to produce paper?

      Should wood resources be depleted to make unnecessary paper products?

   c. Why do certain molecules polymerize and why do polymers have certain properties?

      How could plastics be made at a lower cost, be more efficient, or have expanded application?

   d. Why are properties of synthetic fibres so varied?

      How could properties of synthetic fibres be improved or new applications be found for greater use?

Section 3: Activity 1

1. Testing glass properties may necessitate using high temperatures. There is also a danger from breakage.

2. Testing wood properties may require a large collection of softwood and hardwood samples which could be a problem.

3. Testing of fibre and plastic properties may need sophisticated laboratory equipment, devices, and instruments not readily available in a school laboratory.

4. Limitations that you would encounter in conducting some of the testing listed could include using certain procedures with which you are unfamiliar.

5. a. Probably a ballpoint pen works best due to the dry ink which is not absorbed by the porous paper.

   b. The felt tip pen is the worst due to having a wet ink which is absorbed by the porous paper.

6.

Stain	Cold Water	Hot Water	Hot Soapy Water	Rubbing Alcohol
blood	✓			
ink				✓
grease			✓	✓
coffee	✓	✓		
juice	✓	✓	✓	
nail polish				

7. A suitable title could be *Removing Stains from Cotton.*

8. a. Blood, coffee, and fruit juice were removed in cold water.

   b. Coffee and fruit juice were removed in hot water.

   c. Oil or grease and fruit juice were removed in hot soapy water.

   d.. Grease and ink were removed in rubbing alcohol.

9. Nail polish was not removed by any of these methods.

10. A stain is similar to a dye in that it is a colouring that penetrates fabric fibres.

11. The same tests would probably work with nylon.

12. Stains would not have a chance to penetrate the fibres if they are treated promptly.

13. Fabrics should be tested for colourfastness because treatment methods could remove or change the colour.

14. a. Wool and silk fabrics should not melt on a metal lid, they should burn quickly, they should turn black when burned, and they should bend.

    b. Cotton and silk fabrics should not melt on a metal lid, the fabrics should burn slowly, they should turn a light colour when burned, and they should bend.

    c. Polyester fabrics should melt on a metal lid, the fabrics should burn slowly, and they should turn a light colour when burned.

    d. Nylon fabrics should melt on a metal lid, the fabrics should burn slowly, and they should turn a dark colour when burned.

e. Acrylic fabrics should melt on a metal lid and the fabrics should burn slowly. Dynel will snap and orlon will bend.

15. Acetate fabrics should melt on a metal lid and the fabric should burn quickly.

16. Since different methods were used to achieve tie-dyeing, each sketch will be a unique work of art.

17. Tie-dyeing a fabric produces patterned effects from the uneven absorption of dye due to tight and loose areas exposed to the dye.

18. In tie-dying, the entire surface can be dyed, whereas in batik certain areas resist dyes.

19. a. The mixture tends to resist the pressure of your fingers or hand when they are placed into it quickly.

    b. The mixture changes shape when your fingers or hand are placed into it slowly.

20. The mixture tends to resist the pressure of your hand or fist when you hit its surface.

21. The mixture is a polymer because the starch from which it is made is a polymer.

22. The mixture has an elasticity similar to synthetic rubber.

23. Adding colour illustrates that fabrics, wood, paper, ceramics, leather, plastics, and other materials are commonly coloured or dyed.

Section 3: Activity 2

1. Calculators or portable radios could be made from plastic, metal, and ceramic materials.

2. Paper products are widely used because they are inexpensive, they have a wide assortment of textures and thicknesses, and their raw materials are abundant.

3. The newspaper industry uses the most paper.

4. Chromium-plating transfers its very shiny property to the surface of the paper. Shiny photographs were produced by the same method at one time.

5. Other objects that use glass lenses are eye glasses, binoculars, and magnifying glasses.

6. Some uses of curved glass include magnification, lenses for various instruments, and the starting of fires.

7. Empty bottles are one likely source of curved glass which can start forest fires.

8. Glass used to make labware is called Pyrex.

9. A greenhouse or car with its windows closed gets hot because glass allows infrared radiation from the sun to enter but not leave it. The air molecules trapped inside absorb the radiation as heat.

10. Uses for coloured glass could include traffic lights, signs, stained glass windows, lamp shades, jewellery, and other art forms.

11. Oxides that produce the following colours are

red:	gold or selenium	brown:	iron
violet:	manganese	yellow:	uranium or silver
blue:	cobalt		

12. When birds fluff their feathers during winter, they keep warm because of the insulating dead air spaces between their feathers.

13. Inuit keep warm by wearing loose clothing. Body heat is trapped by the insulating dead air spaces between the body and clothing.

14. A woollen sweater is warmer than a leather jacket because of the insulating dead air spaces in the knit.

15. It would not make sense to wear woollen clothing during summer because wool insulates body heat. It is not water-resistant, it absorbs sweat, and it prevents evaporation of sweat which is a cooling process.

    On the other hand, people in hot, arid areas purposely wear layers of woollens for protection.

16. Common items made from wool would include the following:

    - sweaters
    - blankets
    - socks
    - skirts
    - scarves
    - mittens
    - afghans
    - yarn

17. Nylon is used to make lightweight pup tents. It is water-resistant.

18. Nylon is not water absorbent and retains body heat.

19. Synthetic fibres used as insulation fillers in a jacket or ski suit are warm, lightweight, and comfortable.

20. Fabrics that can be made from cotton fibres are denim and canvas.

21. Precast concrete speeds up time of construction. It does not require the construction of forms needed for pouring of concrete and relies on prefabricated sections which are already made to specifications and tested.

22. Concrete cribbing is a concrete structure used for intake of water, piers, or storage enclosures such as silos.

23. Precast concrete is strengthened with iron rebar or wire mesh.

24. Using bricks to build schools, hospitals, and other large buildings could prolong the life of the institution, increase its fireproof property, and allow for easier future expansion or modification.

25. Ceramic tiles are used in areas such as showers and kitchen and bathroom counters to prevent damage to walls from water backsplash.

26. An extrusion plastic is one that is made by forcing the plastic material through an opening in a continuous manner.

27. Answers may vary. Consumers will want the prices as low as possible and the product inside easily gotten out. Environmentalists will want to use reusables to reduce waste.

28. a. Plastic garbage bags and grocery bags prevent unpleasant odours from escaping. They are sanitary.

    b. Plastic does not decompose. Nonrenewable resources are needed to make plastic.

29. Polyethylene plastic is used for labware because it is tough, unbreakable, transparent, and chemical-resistant.

30. Electrical wiring tools are commonly covered with plastic to prevent electrical shock. Wire is coated with plastic by extrusion to prevent electrical fires and shock.

Section 3: Activity 3

1. a. Rectangular-shaped plastic containers take less storage space than round metal containers. They are easier to package, store, and display, as well as being more convenient to open and pour.

   b. Metal can be recycled. Plastic adds to the waste disposal problem.

2. Decomposers need enzymes in order to break the bonds between molecules and atoms.

3. In order for garbage to decompose it must be biodegradable. Decomposers and specific enzymes must also be present.

4. When garbage is decomposed it is broken up into atoms and molecules which can be reused.

5. Scientists are searching for organisms in the environment that have the enzymes necessary to break down or digest plastics. Perhaps the problem will be solved in the future.

6. If there were no decomposers, the Earth would be a gigantic garbage dump by now. Materials would accumulate and would not break down; therefore the atoms in these materials could not be recycled.

7. Atoms are reused or recycled.

8. Some synthetic materials may not be biodegradable.

9. Plastic products or uses that should be banned or discontinued in favour of other materials could include polystyrene cups, plastic grocery bags, plastic hamburger boxes at fast food outlets, plastic milk pouches, and plastic cutlery.

Section 3: Follow-up Activities

Extra Help

1. a. C, D
   b. A, F
   c. C
   d. C
   e. A, B, E
   f. B
   g. B, C
   h. C
   i. A, B
   j. A, B

2. a. The method used to remove blood stains from cotton fabric is to use **cold** water.
   b. Concrete is made by using **cement**, **water**, and **fine gravel (aggregate)**.
   c. Iron rebar is used to **reinforce** concrete.
   d. The material used to seal the porous pulp used in making paper is called **size**.
   e. The largest user of paper is the **newspaper** industry.
   f. Shiny paper is made by winding paper onto large drums coated with **chromium**.
   g. Curved glass is used to make lenses because it is **transparent** and **bends light**.
   h. Glass used to make laboratory glassware is called **Pyrex**.
   i. To make red coloured glass, an oxide of **gold** or **selenium** is used.
   j. A natural fibre that is used to make denim is **cotton**.
   k. One use for cement cribbing is **culverts**, **sewer mains**, **or well casing**.

l. ABS and PVC plumbing pipes and fixtures are made by the **extrusion** process.

m. A plastic material used to make insulation sheets is **polystyrene**.

n. Extrusion coatings are commonly applied to **wires** and **tools**.

3. a. **F** Some synthetics are nonbiodegradable.

b. **F** The action of decomposers is one of the processes that breaks down materials in the environment. Chemical action is the other.

c. **T**

d. **F** Animals are consumers.

e. **T**

f. **F** Atoms are recycled.

g. **T**

h. **F** An enzyme is matched to break down a specific substance.

i. **T**

j. **T**

k. **F** Biodegradable materials are decomposed in a sanitary landfill.

l. **T**

Enrichment

1. Answers will vary. Your report should include two to five ideas on how to manage solid waste.

2. Your answers will vary depending on which ten items you selected.

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